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ABSTRACT

The provision of network access, resources, and services to members of the academic community is becoming an area of utmost interest and importance to academic administrators, faculty, and students. As the demand from network users grows rapidly, many network administrators are asking for resources to meet that demand; their requests are being met with questions about the costs, uses, and effects of networking at their institutions. In most cases, the information required to answer those questions is not available, nor are the tools with which to collect that information. This investigation attempts to characterize the current state of networking in academic institutions and to identify and develop tools and approaches to assess academic networking. Data was collected primarily through focus groups, interviews with individuals and small groups, and site visits to selected academic institutions. The primary method of data analysis was content analysis. Results of the study indicate: (1) there are multiple barriers to the assessment of academic networking; (2) there is little current assessment of academic networking; (3) there is an interest in assessment of academic networking and a need for assessment tools and techniques; and (4) among the tools and techniques desired are guidelines for conducting qualitative assessments, a set of quantitative measures, and a user survey instrument. (Contains 94 references.) (Author/SWC)

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Assessing the Academic Networked Environment:

FINAL REPORT
July 15, 1996

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1. INTRODUCTION

This document is a final report of the research project, Assessing the Academic Networked Environment, funded by a Research and Demonstration Grant from the U.S. Department of Education, College Library Technology and Cooperation Grants Program. This research project was conducted by a team of faculty and graduate students at Syracuse University's School of Information Studies.[1] The study began in October, 1994, and was completed in April, 1996. Background to the research as well as the methodology and findings are reported here.

Another product of this research is an assessment manual.[2] The manual is a collection of strategies and options for assessing networking which were developed as part of this investigation. Included in the manual are qualitative assessment techniques, quantitative performance measures, and a survey instrument for obtaining network users' perspectives.

1.1. Purpose of the Research

The provision of network access, resources, and services to members of the academic community is becoming an area of utmost interest and importance to academic administrators, faculty, and students. As the demand from network users grows rapidly, many network providers are struggling to meet that demand and their requests for resources to do so are being met with questions about the costs, uses, and effects of networking at their institutions. In most cases, the information required to answer those questions is not available nor are the tools to collect that information. It is within this context that this investigation was conceived.

The purposes of this research were: to define and describe the academic networked environment and its component parts; to identify existing measures of network performance and impacts; to identify factors which facilitate or inhibit network assessment; and to develop and operationalize additional measures. Following are the research questions which guided this investigation:

- What information technologies and services comprise networked information, and to what degree are these similar across various academic institutions?
- Who are the "users" of networked information within the academic setting and how might we develop a typology of such users?
- What are the organizational structures used in academic institutions to provide networked information services?
- What are the key factors that appear to affect the overall success of the networked environment in an academic setting?
- What measures can be developed to assess the impacts of networking on the academic environment?

These questions formed the foundation on which this investigation was conducted to characterize the current state of networking in academic institutions and to identify and develop tools and approaches to assess academic networking.

1.2. Overview of the Report

Included in this report are: a review of relevant research and information resources which constituted the background that informed this investigation, a review of the methodologies employed in this investigation, and the results of this investigation.

Because the assessment of academic networking has not been the focus of much previous research, the relevant published literature is minimal. For this reason, the background investigation went beyond the published literature to include a review of existing sources of data on computer use at academic institutions and an analysis of information technology (IT) plans produced by a selected group of academic institutions.

The focus of this investigation was on academic institutions which meet the criteria for Carnegie Research I and II institutions and which are also members of the Association of Research Libraries (ARL). The methodology used in this investigation was an evolving one, combining a

variety of qualitative techniques for data collection and analysis in an exploratory approach. Data were collected primarily through focus groups, interviews with individuals and small groups, and site visits to selected academic institutions. The primary method of data analysis was content analysis.

Results of this study indicate the following:

- There are multiple barriers to the assessment of academic networking.
- There is little current assessment of academic networking.
- There is an interest in assessment of academic networking and a need for assessment tools and techniques.
- Among the tools and techniques desired are: guidelines for conducting qualitative assessments, a set of quantitative measures, and a user survey instrument.

Thus the primary contribution of this study is a framework for academic network assessment which is suitable for field testing by academic institutions. This framework is not a guide nor does it encompass step-by-step procedures in a start-to-finish approach to assessment. However, it does provide a starting point for institutions which are interested in assessment. The tools, techniques, and measures developed during this investigation are by no means presented as appropriate for all institutions. Rather they are presented as a menu of items from which institutions can select. The study team which conducted this investigation anticipates that individual institutions will begin implementing and further developing these tools, techniques, and measures in order to determine which of them work best in certain kinds of institutions. The study team further expects that these tools, techniques, and measures will evolve over time as they are field-tested and fine-tuned by institutions.

Notes to Section 1

1. Co-principle investigators for the study were: Cynthia L. Lopata, Assistant Professor; and Charles R. McClure, Distinguished Professor. The following graduate students also contributed to this investigation: Bill Boroson, Anne Diekema, Kristin Eschenfelder, Bill Gibbons, Denise Masters, Makiko Miwa, Diane Sotak, Claire Urfels, and Jean Van Doren.

2. This manual, Assessing the Academic Networked Environment: Strategies and Options, is available from the Coalition for Networked Information (CNI), in Washington, DC. For order information email pubs@cni.org or call 202-296-5098.

2. BACKGROUND

2.1. Introduction

The assessment of networking in academic institutions is a topic which has not been well researched to date. In fact, assessment of networking in general, and more broadly of all computer technologies, to determine their impacts on the organizations which have adopted them is an area about which little is known. Thus there was not a great deal of previous research to form a foundation on which to build this investigation. The study team consulted a variety of sources, in addition to the published research literature, to identify and collect information which might inform this study. Results of the background investigation which preceded, and formed the foundation of, this study are presented here in four parts: a review of relevant literature, a review of existing network models, a review of existing sources of relevant data, and an analysis of existing plans for IT development and support at academic institutions.

2.2. Literature Review

This section reviews the literature on measurement and evaluation of computer-based information systems and network-based technologies, resources, and services. Although the specific context of interest for the study is the academic setting, the review also considered other contexts, e.g., business, in the hope of identifying studies that had the potential of being useful in an academic setting. This review covers literature from the fields of education, business/management, library/information science, and computer science. The review focuses primarily on literature published within the last ten years and, rather than being exhaustive, highlights selected studies and reports which are representative of certain segments of the broader literature. The objectives of the review were to:

- Assess the degree to which successful measurement and evaluation of networked and computer-based services occurs.

- Understand better the barriers that inhibit successful measurement and evaluation of networked and computer-based services.
- Identify approaches that may be useful for developing measures to assess the impacts of networking in an academic setting.

There is much support in the literature for the measurement and evaluation of IT and networking in academic institutions. According to Heterick (1994), "Our colleagues want such measures, our legislatures and funding agencies are demanding such measurements, and the future health and well-being of our profession require such measurements" (p. 64). Fleit (1994) says that, "The combination of greater scrutiny brought on by both increased visibility and a growing demand for accountability make this an excellent time to do an assessment of the institution's information technology" (p. 3).

In spite of this generally recognized need for assessment, the literature reveals few attempts to develop applicable measures or to conduct assessments of IT and networking in academic institutions. McClure (1991) gives several reasons for the lack of research in this area. First, the evolution of the academic network has been incredibly fast, leaving the participants with barely enough time to stay abreast of new technologies let alone time to study the developments. Second, academic environments are typically slow in providing evaluations and a "culture" of ongoing evaluation is virtually nonexistent. And third, the development of useful, feasible, and meaningful measures is extremely difficult.

In reviewing the relevant literature, the study team identified four major categories of research: program and services evaluation, IT measurements in business, IT measurements in education, and IT measurements in libraries. Each of these categories is reviewed in a separate section below.

2.2.1. Definitions

A number of terms are used repeatedly throughout the various literatures reviewed here.

These often-used terms are defined below.

Measurement is the process by which numbers are assigned to describe some object or phenomenon in a standardized manner. As Kaplan (1964) writes, it "is a device for standardization, by which we are assured of equivalences among objectives of diverse origin"(pp. 173-174). Measurement may or may not lead to evaluation; evaluation often requires measurement.

Evaluation is the process of identifying and collecting data about specific services or activities, establishing criteria to assess their success, and determining the degree to which the service or activity accomplishes stated objectives. As such, evaluation is a decision making tool intended primarily to assist decision makers to allocate resources that best accomplish organizational goals. Evaluation reflects value judgements on the part of the evaluator regarding the adequacy, appropriateness, and success of a particular service or activity..

Performance measures represent a broad managerial concept that encompasses measurement of both inputs (indicators of the resources essential to provide a service) and outputs (indicators of the services resulting from the use of those resources). The primary purpose of a performance measure is to serve as a self-diagnostic for the organization. Simply stated, performance measures ask decision makers to answer the question: How well is the service or activity doing what it claims to be doing?

Information technology is described by Emery (1987) as "the technology associated with the computer hardware, computer software, and communications" (p. 317). Tanenbaum (1981) described a computer network as an "interconnected collection of autonomous computers. Two computers are said to be interconnected if they are capable of exchanging information. The connection need not be via a copper wire; lasers, microwaves, and earth satellites can also be used" (p. 2). According to Boyce, Meadow, and Kraft (1994), "An information system is a set of components whose combined purpose is to acquire, process, and transmit information" (p. 5).

2.2.2. Program and Services Evaluation

The evaluation of programs and services is one area of the relevant literature where a significant amount of research has been done. Much of this research applies to libraries, although some of it applies to other types of organizations, including computing centers and information systems departments.

Library administrators and researchers alike have struggled for years to measure and evaluate the different programs and services provided by their libraries. Traditionally the measurement of library services has mainly focused on output measures but it has recently evolved into more meaningful measures like impact measures. The literature on measuring library services is quite extensive (e.g., In Service to Iowa, 1989; Library Programs, 1990; Lynch, 1983; McClure, 1986; Murphy, 1987; Owen, 1991; and Shaughnessy, 1987).

King and Griffiths (1991) established four general categories of measures for use in libraries and information centers: size, goodness, use, and usefulness. Within these general categories, they developed a variety of more specific measures, including:

- Input measures including amount of resources (e.g., staff, equipment and systems, facilities, collection, etc.) applied to operational functions and services, amount of funds/money applied and relevant attributes of resources applied (e.g. staff competencies, equipment reliability, etc.);
- Output measures including quantities and attributes of output such as quality, timeliness, availability and accessibility;
- Effectiveness measures including amount of use, user's perception of output attributes, user-expressed satisfaction with services and specific attributes, user-indicated importance of services and attributes, purposes of use and consequences of use of services.
- Service domain measures including total population size and attributes, user population size and attributes, size and attributes of geographic area and information

needs and requirements.

According to King and Griffiths (1991), combinations of measures which represent the relationships among them are even more meaningful than individual measures. They developed the following indicators, based on such combinations:

- Operational performance indicators which relate input and output measures and their attributes (e.g. productivity-output divided by input, cost per transaction at various levels of quality, etc.);
- Effectiveness indicators which relate output quantities and attributes to use (e.g. extent of use as a function of quality and timeliness of services);
- Cost-effectiveness indicators which relate input cost measures, effectiveness measures and domain measures (e.g. cost per use, cost peruser, cost per capita);
- Impact indicators which relate actual use or needs to potential use or needs (e.g. users per capita, use per capita, needs fill rates, etc.).

King and Griffiths (1991) also investigated the economic value of library services by examining:

- What users are "willing to pay" (i.e., as demonstrated by what they actually do pay) for information provided by special libraries, in terms of their own time to locate, obtain and use the information and monies paid;
- The difference in the cost of using library services and what it would cost to use alternatives, if the services were not available; and
- The "savings" obtained from reading library-provided materials that would likely be lost if the services were not available (based on the assumption that the total "willingness to pay" as defined above would not change).

One library service that has been studied intensively is reference. There have been two major approaches in evaluating reference: quantitative measurement and qualitative measurement. Gorman's (1987) book is based on two surveys, one for quantitative and one on qualitative

measures. Quantitative measures focus on the number of reference interactions completed, the time to complete them, etc. The object of study in measuring the quality of reference services is the reference question outcome. Hernon (1987) and Bunge (1990) discuss measuring success rates in answering questions rather than just gathering reference statistics. Hernon and McClure (1987) suggest that reference services can be measured unobtrusively. Murfin and Gugelchuk (1987) describe an instrument that judges the success of a "reference outcome" based on what the patron wanted to find. Green (1988) stresses the continuous measuring of reference service effectiveness.

Beyond the measures described above, which relate to specific programs and services, other measures of institutional performance also encompass the evaluation of such programs and services. Orr's schema as described by Buckland (1992) may be used for measuring the quality and value of libraries at the institutional level. Buckland concludes that each concept is quite different from the other and both are difficult to measure. Other research on measures at the institutional level includes: McClure et al. (1992), who addressed the creation of an international standard for library performance measures; Shaughnessy (1990), who wrote about library effectiveness; and Afshar (1991), who provided a theoretical basis for measuring the quality of institutions of higher education.

Program and service evaluation are also encompassed in institutional assessment measures which were developed for academic computing organizations. Fleit (1994) provides a number of close-ended questions on topics such as planning, policies and procedures, facilities and staff, products and services, organization and external relationships, and funding. Computing centers can use these questions to do self-evaluations. Rubin (1991a, p. 77, 78) provides ten possible metrics to gauge the performance of the information systems department:

1. Productivity metrics. These measure the software delivery rate and ability to support software.
2. Quality metrics. These measure the technical quality of the software produced and

maintained, the software's functional quality in the context of meeting business needs and the quality of the software engineering process.

3. Delivery metrics. These measure the organization's ability to meet time and cost commitments.
4. Penetration metrics. These measure the extent to which tools and techniques have been successfully disseminated.
5. Work profile metrics. These measure the effort and elapsed time it takes for work to progress through life cycle stages.
6. Demand metrics. These measure request backlogs and the organization's ability to service them.
7. Technology assimilation metrics. These measure the organization's ability to adopt and assimilate promising new software engineering technology.
8. Work distribution metrics. These measure the balance between maintenance and development.
9. Capability metrics. These measure the ability of the organization to manage, measure and improve itself.
10. Business-oriented metrics. These link IS functions to the success measures used by the business to gauge business performance.

2.2.3. IT Measurements in Business

Carlson and McNurlin (1992a) observe that trends such as total quality management and business process reengineering have focused the business community's interests on evaluating the contribution of IT to their organizations' success. The management literature on the evaluation of IT is extensive and can be subdivided into: general information system measures, value of information systems, information system performance, quality and effectiveness of information systems, productivity of information systems, and measurement of end-user satisfaction.

According to Rubin (1991a, 1991b) effective information systems measurement programs involve both information systems measures and business measures. In order to decide which measures to use, an organization has to complete several steps (Rubin 1991c, p. 79):

- Identify all audiences for measurement and measurement stakeholders[1]
- Analyze the measurement needs of each audience and stakeholder[2]
- Produce a map that cross-references audiences to needs
- Produce a map that cross-references needs to possible metrics
- Decide which candidate metrics to use
- Establish priorities and a phased implementation plan.

These steps will result in two matrices that provide organizations with an overview of all necessary measurements. This solves the problem, identified by Carlson and McNurlin (1992b), of deciding which performance measure to use in a given situation.

In the literature on the value of information systems the importance of measurement is discussed, but few useful measures have been proposed. Ryder (1988) and Sullivan-Trainor (1989) stress the need for measuring the business value of IT or facing budget cuts. Lane and Hall (1989, pp. 73-74) provide six general principles that should form the groundwork for the actual measurement rules but do not suggest exactly how the value should be measured. These are:

- Recognize information systems as an asset-based function
- Agree on how to quantify intangible value
- Value existing technology as a point of departure
- Establish a procedure to "investment justify" systems projects
- Review and update the valuation on a regular basis
- Integrate the systems-valuation process into business planning

A welcome exception is Kanter's (1987) description of the value chain evaluation method which compares the cost of producing a service or product to the price customers are willing to pay. Campbell (1992a) explains that in banking the value of IT can be assessed by measuring the

effect on the four income drivers[3] since these comprise the bulk of a bank's net income.

The literature on information systems performance discusses measures like the Real-Time Kernel (RTK)[4] performance (Berggren, Gustafsson, and Lindh, 1992). This study suggests that measuring the performance of the RTK can be useful to establish the usage of a RTK or to compare different RTK's. Baccelli and Fayolle (1983) combine computer science with probability analyses to evaluate system performance. Some authors like Heterick (1994) have been questioning these traditional system performance measures while others suggest using them in combination with other measures (Lane and Hall, 1989).

Slevin, Stieman, and Boone (1991) discuss the critical success factor (CSF) process as a measurement of performance. Instead of using the key areas of an organization for planning purposes, they can be used to design performance measures. In this case study, conducted in a university environment, the authors tried to define specific critical success factors for each department and determine how each could be measured. The CSF method enables "measuring the performance of a technologically sophisticated set of services provided to a variety of users" (p. 170).

Evans, et al. (1988) describe four methodologies to evaluate a system's effectiveness:

- The IDEF methodology for understanding an environment, its functions, relationships, and information flow
- The Bailey and Federle Methodology for understanding user needs and potential for computer support
- The Krobock Methodology for determining utility of information systems
- The Pearson Methodology for determining user satisfaction with information systems (p. 235).

The IDEF methodology models information flows and functions in an environment in order to make the workings of an organization more clear. In the Bailey and Federle methodology users identify their key tasks, rank them according to importance and time spent on them. Using this

methodology provides insight into users' work and their information needs. The Krobock methodology "measures multiple factors which affect information usefulness including timeliness, currency, accuracy, relevancy, adequacy, useability, and handiness" (Evans et al. 1988, p. 227). The users themselves decide on these factors. The above methods can be used individually or in combination with each other. The Pearson Methodology "uses a semantic differential technique to rate 39 factors which cause satisfaction or dissatisfaction with information systems" (p. 228).

Although the quality of an information system is often intangible, there have been some attempts to develop measures of this quality. Rivard and Kaiser (1989) suggest using focus groups, in-depth interviews, expert opinion, the Delphi technique, observation, benefit profile charts, and existing systems analysis methods to help measure quality of information systems.

A series of studies investigating the relationship between IT and organizational productivity describes this phenomenon and refers to it as the productivity paradox (Brynjolfsson, 1993). This research suggests that even though companies may invest a lot in IT, this may not increase productivity. Much of the literature on the productivity of information systems focuses on this idea of the productivity paradox (e.g., Dubashi & McGough, 1992; Due, 1993; Freeman, 1989; Krohe, 1993; Laberis, 1993; Lane & Hall, 1989; Magnet, 1994; McGough, 1992; McGovern, 1993; Shaw, 1994; Strassman, 1985, 1990).

This productivity paradox might be due, in part, to the use of inappropriate measures. Researchers used traditional productivity measurements[5] that, according to Brynjolfsson (1993) "fail to account for *nontraditional* sources of value" (p. 73). Values like quality increase and increased customer satisfaction due to better and faster service are intangible and difficult to measure. Some studies also failed to take time into account. It can take several years for benefits to appear in the form of improved productivity. It could also be that using IT might be profitable only to some companies or that we need to learn how to manage IT before it will become profitable (Brynjolfsson).

Krohe (1993) explains that investing in IT does not always pay off because computers can

do things faster but not necessarily better. The extra time gained by using computers might be lost once people have learned how to use them and after computer problems have been solved. According to Krohe the average PC user wastes 5.1 hours a week "futzing" with the computer. This phenomenon, also called the electronic sandbox, is described as a virtual place where people go to play computer games and chat.

Koenig and Wilson (1996) give several additional reasons for the productivity paradox. First, there seem to be some benefits of IT that are simply not captured by any productivity measures. For example, "What is the utility of higher definition television, or of a vastly increased number of channels?" (Koenig and Wilson, 1996, p. 2). Second, there are benefits that could be measured but are not. One example of this type of benefit is increased customer satisfaction. Online information resources such as Chemical Abstracts or Beilstein may not have affected sales in the pharmaceutical industry, however, the pharmaceuticals being produced might be more effective. Third, the benefits of IT are often lost in maintaining a competitive advantage. Using IT as a product differentiation enabler might spoil productivity gains. And lastly, Koenig and Wilson mention that the productivity measures might not be useful in a service industry.

As shown in the previous paragraphs, benefits from IT can come to an organization in ways other than those which productivity measures tend to capture. As Krohe (1993) said, "Applying conventional economic indexes to computer productivity... is like measuring air pressure with a ruler" (p. 19).

Lee (1988) suggests that the classic productivity measures of output and input pose problems in the case of IT since the outputs are so difficult to identify and measure. This view is shared by: Allen, 1986; Duncan, 1992; and Rudd, 1993,who blames the nature of information for the productivity measuring difficulties. Belitsos (1988) rightly points out that the traditional input and output measures will remain in use until new ones are accepted.

Yet some contend that the productivity of information systems is measurable. Oman and Ayers (1988) distinguish five aspects of productivity to which a cost benefit analysis can be

applied:

- Document output productivity
- Secretarial/clerical productivity
- Professional/managerial productivity
- Office productivity
- Organization productivity

Document output productivity "is determined by comparing the volume of documents or documentation produced per time unit on conventional equipment to the volume of documentation produced using automated information technology" (Oman and Ayers, 1988, p. 33). Measuring the secretarial/clerical productivity involves measuring quality of service, the rate of personnel turnover, morale and status of secretarial/clerical functions. Professional/managerial productivity can be measured by looking at "the effect of information technology in saving professional time on document creation and revision and on the ability of information systems to improve the access to and quality of information" (p. 34). Office productivity "is measured by the contribution of the office system to the efficiency and effectiveness of the overall organization" (p. 34). Organization productivity explores "the effect of information technology on productivity by examining the impact on achieving organization goals" (p. 34). Oman and Ayers further provide three benefit-cost models that can be used on one or more of the five productivity approaches. The first is the cost-reduction model that is based on the assumption that automation will lead to reduced labor costs. The second model examines the "benefits of information technology while assuming the costs stay the same" (p. 36). The third is a mixed costs/benefits model.

Tayntor (1994) suggests combining metrics and productivity programs which means quantifying services and demonstrating productivity. Scudder and Kucic (1991) recommend the use of multiple measures dealing with efficiency as well as effectiveness. A list of "overall performance measures" (p. 350) describes measures concerning personnel performance (e.g., business knowledge, technical capabilities), managerial performance (e.g., performance audits,

attitudes of users), developmental performance (e.g., staff turnover, documentation quality), goal setting (e.g., quality of planning, forecast of future IS capabilities), operational performance (e.g., user interaction, timely output), and financial performance (e.g., budget performance, cost recovery).

Another productivity measure is the function point analysis. As described by Bock and Klepper (1992), it is used to measure the work output of information systems. Originally developed by Albrecht, the function point analysis counts and projects deliverables of an application by looking at the number of inputs to the application, the number of outputs from the application, the number of inquiries an end-user can make, the number of logical data files used by the system, and the number of interfaces to other publications. Function points are calculated for each deliverable. Jebber (1992) and Laplante (1991) both describe computer packages that measure productivity. The measures used by these packages range from the number of lines of code to industry benchmarks to compare and contrast how an organization is doing.

Two aspects of this paradox may be considered as they relate to the academic environment:

- The culture of the academic institution, in contrast to the for-profit, business environment, may not inherently possess a strong inclination to maximize efficiencies in the deployment of information technologies. Such a scenario would be analogous to Roach's (1991) assessment of information technology in the service sector in which he suggests that economic protection, afforded this sector, contributed to expenditures without sufficient regard to efficiencies, resulting in negative productivity gains.
- A 1994 study, commissioned by the Computer Science and Telecommunications Board (CSTB) of the National Research Council, concluded that, for service organizations, many of the macroeconomic measures of productivity mask or overlook critical performance assessment criteria which may be derived through a more qualitative methodology. Of particular significance for academic institutions

> would be those performance measures associated with the overall quality of service provided to their constituents (CSTB, 1994). In fact, many participants in this study were led to conclude that "the whole concept of productivity, as it is currently measured, may be outmoded and that other measures of performance provide a better indication of the contribution of information technologies" (CSTB, p. 29).

Doll and Torkzadeh (1991) measure user computer satisfaction using Likert scales, which they believe are very useful tools in discovering a respondent's beliefs. Arkush and Stanton (1988) measure the value of end-user computing by calculating a sample value (sample benefits minus sample costs) instead of a total value. Although calculating a total value is more precise, they reason that using only a sample of the total user population and extrapolating the results is a much more cost-effective way to measure.

Some authors suggest evaluating the performance of the information systems department (not just the system) by asking users about the department's performance. In a roundtable discussion documented by Rhodes and Chester (1987) the users' role in evaluation is also mentioned.

2.2.4. IT Measurements in Education

Henry et al. (1993) discuss the possible effects of networks on the way information is being transferred. Communication between disciplines is easier and more projects will be completed collaboratively. Also the scholarly publication process is likely to change. Rickman and Hubbard (1992) provide a description of the features of the electronic campus system of Northwest Missouri State University (Maryville).

Anderson and Draper (1991) show the wide range of areas involved in the evaluation of learning. Evaluation of learning involves research on mental representation, learning mechanisms, motivation, teaching, didactics, teaching methods and media, social interactions and institutional factors. Anderson and Draper argue that IT influences all of these areas thus making the

evaluation of the impact of IT on learning an extremely complex matter. Anderson and Draper also suggest that "educational benefit is not at the level of the medium, but at some finer grained level concerned with how the medium is used" (p. 5).

Goodhue et al. (1993) use a wide scope survey, selected in-depth interviews, and usage statistics to measure the impact of the Integrated Information Center (ICC) at the university of Minnesota. In doing so Goodhue et al. try to measure how technology affects performance. The two premises on which this study is based are: technology must be a good fit for the task, and technology must be used. Only if these two premises are satisfied can performance increase. However, from the article it is unclear as to how the technology fit and the use of technology are measured.

A study using similar data collection methods was done by Wilson et al. (1993) who evaluate the impact of technology at Peakview Elementary School by comparing their networked school to other schools. This study looked at student achievement, the use of technology, and the impact of technology on teaching. Data were collected at the beginning of the school year and at the end of the year in order to identify changes. Data were gathered from students and teachers using written surveys and interviews. Among the things that they looked at were student achievement, use of technology, and impact on teaching. For data interpretation the researchers used bar charts and line charts. They also calculated the chi square or analysis of variance where possible.

Gearhart et al. (1990) describe a program that measures the impact of educational technology by "observing" the classroom at timed intervals. "Snapshots" of classroom activity are created by coding a large number of class routines regularly. These descriptions can be used to report what happens in the classroom and also identify where technology has an impact on teaching and learning. The authors agree that this instrument should be used in combination with other data collection methods in order to be useful. Matthews and Winsauer (1984) offer criteria to evaluate educational software by using concepts from learning theory.

Fleit (1994) is an exception to the literature since she provides a number of clear close-ended questions for academic computing centers to determine how they are providing various services. Many negative answers indicate that the center is in bad shape. The questions are divided among several topics: planning, policies and procedures, facilities and staff, products and services, organization and external relationships, and funding. One weakness of this method is that the opinions of users may be inaccurate and represent only their "perceptions" of the services being provided. Nonetheless, such information can be very valuable.

2.2.5. IT Measurements in Libraries

Lynch (1988) discusses the measurement of system performance based on MELVYL, the online library catalog of the University of California. Lynch recognizes three types of data to be collected: statistical data, benchmark data, and detailed logging data. Performance measures are useful for capacity planning, acceptance testing, quality assurance, and system tuning and refinement. Measuring response time is especially useful in determining user satisfaction. He believes that measures like number of searches, number of displayed records, and number of help screens viewed are of less importance.

Peters (1988) and Schmidt et al. (1988) discuss the possible standardization of performance evaluation of automated library systems. Peters proposes a framework for the development of performance testing of library automation systems. Regazzi (1988) evaluates an information retrieval system by doing an experiment using human subjects to establish relevance of certain documents in relation to search topics. Using relevance, recall, and precision as information retrieval system measures is a much debated subject in the literature (Boyce, Meadow & Kraft, 1994; Eisenberg & Barry, 1988; Froehlich, 1991; Harter, 1992; Janes & McKinney, 1992; Park, 1993; Salton, 1992; Schamber & Eisenberg, 1991; and Schamber, Eisenberg, & Nilan, 1990). Such approaches, however, require sophisticated methodologies that would be difficult for practitioners to use.

2.2.6.Conclusion

Overall, the review of the literature suggests that there have been few research efforts to develop and test measures of the impacts of networking in an academic setting. However, there is much agreement that such measures are important and should be developed. Following is a discussion of some key concepts which have emerged from this literature and which form a foundation for the development of measures relevant to this investigation.

Traditional performance measures can be divided into four assessment indicators: extensiveness, efficiency, effectiveness, and impact (King and Griffiths, 1991; McClure, 1991; Menou, 1994). McClure (p. 37) describes these measures as follows:

- Extensiveness: how much of something has been provided, e.g., number of transactions on a listserv
- Efficiency: the use of resources in providing something, e.g., cost per listserv transaction
- Effectiveness: how well something is done or the degree to which a service met its stated objectives, e.g., number of books cataloged that actually circulated in their first year on the shelf
- Impact: how a service made a difference in some other activity or situation, e.g., grades of freshmen who took a library bibliographic instruction program as compared to grades of those freshmen who did not take the program.

Almost all measures found in the literature can be recognized as belonging to one of these types. Example measures identified in the literature are grouped in the sections below.

Extensiveness Measures. Although extensiveness measures are probably the easiest measures with which to deal, most of the literature agrees that they are not at all sufficient for the evaluation of information systems. These measures are often referred to as traditional measures. Berggren, Gustafsson and Lindh (1992) describe the RTK or real-time kernel performance evaluation. Bock and Klepper (1992) describe the Function Point analyses to measure the output

of information systems. Evans et al. (1988) describe the Krobock Methodology to measure the utility of information systems. Rubin (1991c) uses measures such as the number of lines of code, the number of lines of executable code, and penetration measures (how many people who could use the system are actually using it).

Efficiency Measures. Kanter (1987) and Scudder and Kucic (1991) describe the Return On Investment (ROI) ratio. Campbell (1992b) calculates how technology investment contributes to a bank's net income. Oman and Ayers (1988) and Arkush and Stanton (1988) each do a cost benefit analysis, the former by looking at the different kinds of productivity (office productivity, organization productivity) and the latter by using sample values so things like user satisfaction can be taken into account.

Effectiveness Measures. Effectiveness measures for reference services can be found in Bunge (1990) in the form of success rates of reference question answering as perceived by librarians and patrons. Murfin and Gugelchuk (1987) assess the reference outcome in terms of a patron report. Green (1988) and Gorman (1987) both measure reference effectiveness using different reference criteria for staff, bibliographic instruction, and online services. Fleit (1994) provides questions to aid self-assessment for campus IT. In answering the questions academic computing centers are comparing themselves to an ideal situation. Slevin, Stieman, and Boone (1991) describe using the critical success factor (CSF) process as a performance measurement. Evans et al. (1988) describe the Bailey and Pearson methods to measure user information needs. Rubin (1991a) describes failure intensity (number of failures per time period), technical quality (design strength in relation to operability and maintenance) and functional quality as effectiveness measures.

Impact Measures. In a case study, Wilson (1993) measures the impact of technology in the Peakview Elementary School. By doing a longitudinal study, the changes in students' and teachers' behaviors and attitudes toward technology could be measured.

Two general kinds of measures emerge from the literature: system-based measures and

user-based measures. System-based measures, such as Real-Time Kernel performance or response time, are sometimes referred to as traditional performance measures and tend to measure the technical features of a system. Although system-based measures are more straightforward and easier to quantify than user-based measures, such as user satisfaction, system-based measures are generally believed to be less adequate in evaluating the impact of information systems.

There are many questions concerning the degree to which business approaches are transferable to higher education. It has become clear that traditional productivity measures do not transfer. Koenig and Wilson (1996) suggest that "the standard measure of productivity in a service environment is fundamentally doomed to be increasingly meaningless" and that to have meaningful measures we must totally overhaul the ways in which the productivity of services is calculated (p. 3). Some of the basic concepts of information systems measurement might be transferable but specific measures will most likely differ since the higher education environment differs considerably from that of business.

Traditional system performance measures or technical measures (Baccelli and Fayolle, 1983), such as the number of dialup lines, are described in the literature but the literature also suggests that these should either be ignored or used only in combination with other measures (Lane and Hall, 1989).

Overall, the literature on measures of electronic networked resources and services does not offer actual measures. Even articles with hopeful titles such as "Yes, There Is a Way to Measure MIS Investments" do not go beyond providing general guidelines that one should follow prior to establishing the measures. Authors have a tendency to focus on issues related to measures or the act of measuring, and shy away from the real issue: the actual measures. Notable exceptions are Evans et al., 1988; Fleit, 1994; Rubin, 1991a; Scudder and Kucic, 1991; and Slevin, Stieman, and Boone, 1991.

Heterick (1994, p. 64) expresses concern about the traditional system performance measurements which were merely dealing with inputs. "Computer folk have counted lots of things

for lots of years." Most of those things had to do with arcane details of how systems "performed." Although Heterick calls for measurements of outputs rather than inputs he does not provide details as to what kinds of outputs or how these outputs should be measured.

Part of the literature suggests involving the user in the measurement. McClure (1994) calls for developing performance measures that have a user perspective so that we can better understand "the role, importance, and impact of networked information services in the academic setting."

Reliable and valid measurement and evaluation in the social sciences is extremely difficult. When the measurement and evaluation includes both a behavioral and technological context, it is even more difficult. The literature agrees that measurement of networked and computer-based services is a complex problem. As shown in the previous review of the literature, the ability of researchers to operationalize possible indicators of impacts of networked and computer-based services is extremely limited.

What becomes clear after reading the limited literature on this topic is that little research has been done on the topic of measuring impacts on the academic institution. Related literature provides us with some insight as to what measures and data collection methods are used in various fields. However, the measurement of IT remains a difficult topic. Brynjolfsson (1993) warns us that "Even with substantive improvements in our research on IT and productivity, researchers must not overlook the fact that our tools are still 'blunt'" (p. 76). He goes on to say that we as researchers should be "prepared to look beyond conventional productivity measurement techniques."

What seems to be needed is a usable combination of measures. Not until one combines extensiveness, effectiveness, efficiency and impact measures does one get a complete assessment of networking service. And we need a range of measures which assess networks, information systems and services from a user perspective.

2.3. Assessment of Existing Network Models

One goal of this investigation was to define the academic networked environment and develop a generic and conceptual model of this environment. The study team conducted a review of existing network models to provide a foundation for this model of the academic networked environment. Three of the existing models which were found to be relevant to this investigation are described below.

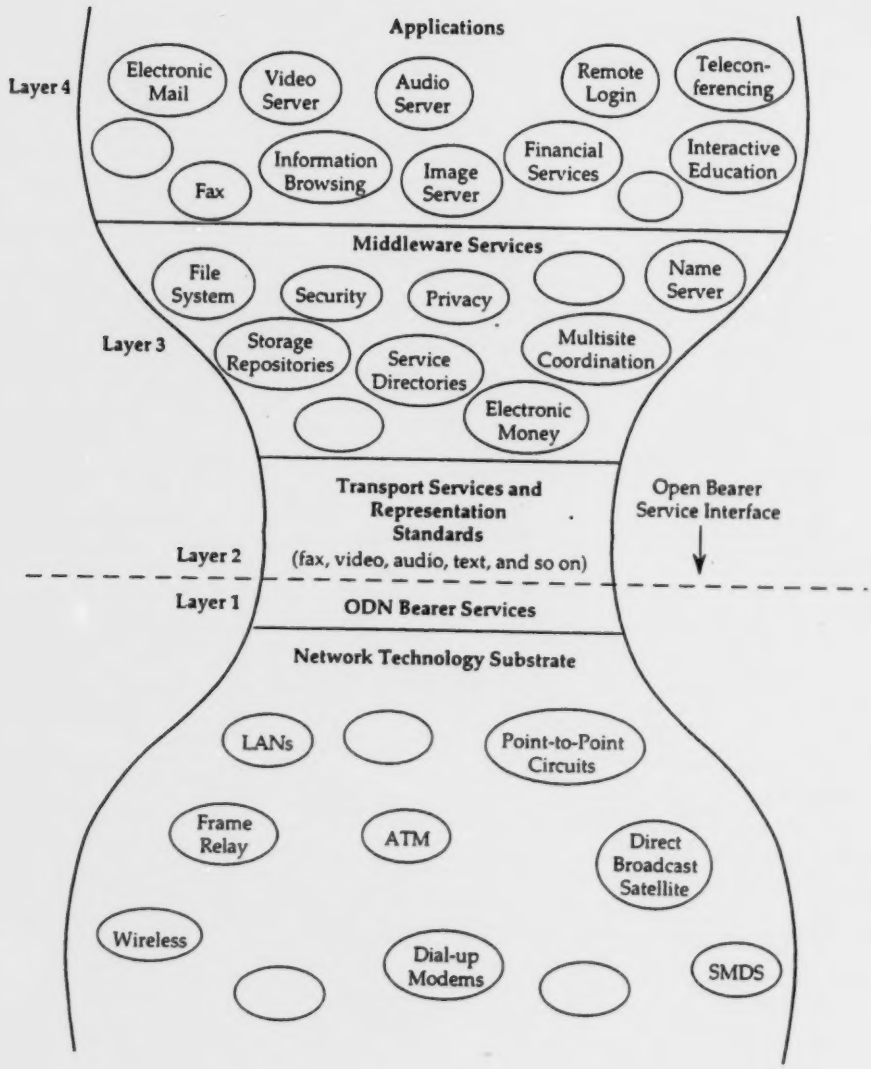
National Research Council Model. The National Research Council (NRC) (1994) developed a set of definitions which are useful in the design and analysis of network models. They include:

- Network: A communications system that connects geographically distributed users with links and switches as well as control software.
- Network Functionality: Networks support communications between programs running on groups of two or more computers. Such programs implement applications that may be running on behalf of one or more individual users. The interchange of data between hosts and users takes place as character streams that pass between them.
- Local Area Networks (LANs) and Wide Area Networks (WANs): LANs are networks that operate in limited geographic areas, such as single buildings or campus settings. WANs connect computers or LANs over larger areas. The most unique and extensive WAN is the network of networks known as the Internet.

The NRC also developed a vision, or model, of what is referred to as the Open Data Network (ODN). The ODN is capable of carrying information services of all kinds, from suppliers of all types, to a variety of customers, across LANs and WANs, in a seamless, accessible fashion. This "openness" in architecture requires relevant standards to be set for the physical infrastructure and offered services as well as for oversight and management of the overall network.

The NRC model (Figure 2-1) offers a highly technical structure of layered connectivity

FIGURE 2-1. NRC MODEL



from the Bearer Service (Layer 1) through the Transport Services and Middleware Services (Layers 2 and 3) into the Applications Area (Layer 4). The path of progression within this model is through all levels in succession until the application is addressed. The model has not been operationalized with the intent to provide quantitative measurements within each layer. Although users are mentioned often within the NRC model, in terms of authenticating, verifying identification, security, and control, users do not represent a fundamental component, nor a unique layer, within the model.

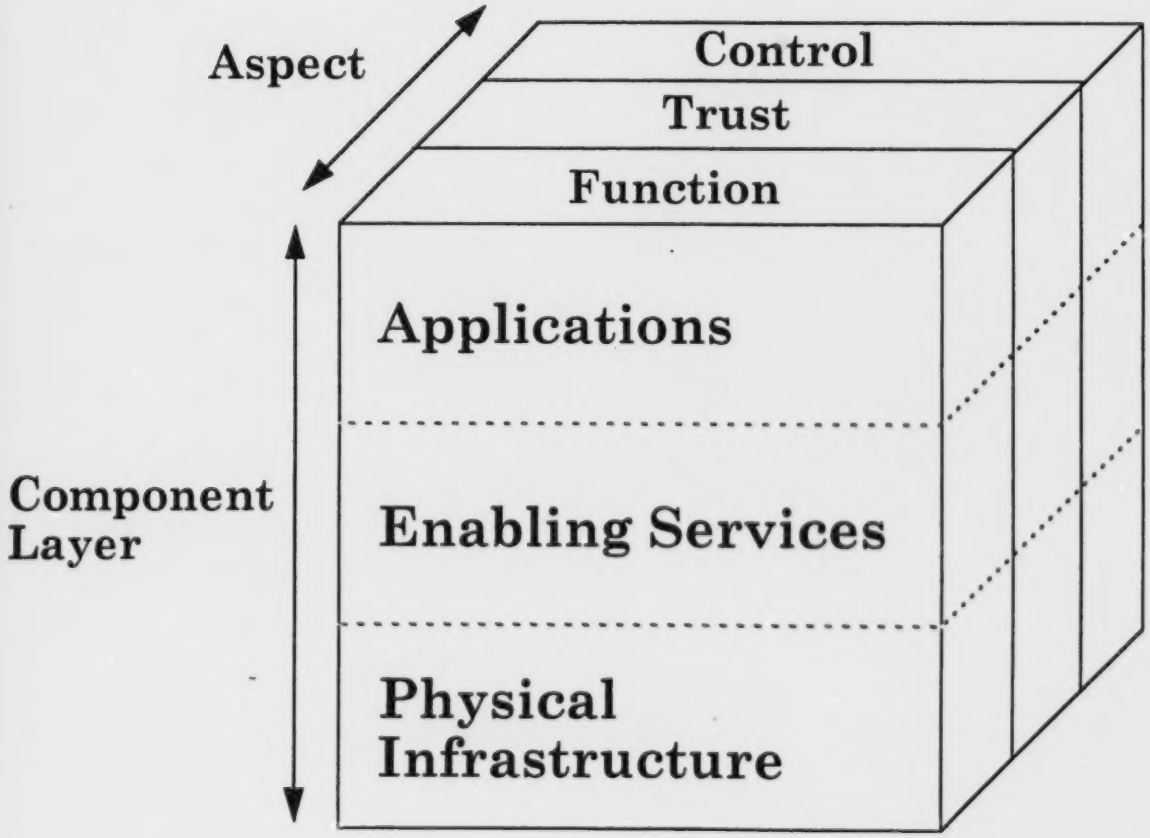
The NRC model provides useful ideas on the composition of highly technical models, especially concerning the interaction of the transport and applications layers. It does not, however, offer insight into assessment or measurement of the effectiveness of networks of this type.

Cross-Industry Working Team Model. The Cross-Industry Working Team (XIWT) of the Corporation for National Research Initiatives (CNRI), has developed An Architectural Framework for the National Information Infrastructure. This framework is the collaborative work of individuals from 41 of America's telecommunications corporations and societies.

This document provides a vocabulary and context for discussing an architecture for the NII, identifies some necessary fundamental NII components and services, and examines ways to expand and evolve the infrastructure. The aim is to allow communications, computer, and information providers to work separately while implementing elements of a common vision. The principles driving this model, called the Functional Service Model, include a feature-rich, open, and distributed architecture, based on functionality, trust, and control (XIWT, 1994, p. 12-17).

The XIWT model includes three component layers: Physical Infrastructure, Enabling Services, and Applications. (See Figure 2-2.) These component layers are tightly bound with three aspect layers: Function, Trust, and Control. As in the NRC model, functionality implies an open architecture, while "trust" includes the concepts of security, integrity, and performance assurance. The control layer includes concepts of management, service, and flexibility, along with the ability to measure, and to provide accounting functions. Although this model emphasizes performance

FIGURE 2-2. XIWT MODEL



measurements, in the form of statistics and descriptions of the component states, it, like the NRC model, does not focus on the user as one of its foundations.

CSPP Critical Interfaces. The Computer Systems Policy Project (CSPP) is an affiliation of chief executive officers of American computing companies that develop, build, market, service, and support information processing software and solutions. Since 1989, this group has been committed to the development of policy positions on trade and technology issues affecting their industry and ultimately the United States (CSPP, 1994).

The CSPP's Perspective on the National Information Infrastructure: Ensuring Interoperability, published in February, 1994, is also of importance in studying the Academic Networked Environment. In this report, CSPP proposes an industry-led strategy to ensure interoperability. CSPP does not suggest a specific architecture, as the other models do, but instead, identifies critical points within the infrastructure that must be interoperable for successful functionality. These interfaces, identified by CSPP, fall into four categories:

1. Appliance (User) to Network: the interface between an information appliance, operated by a user, and a network service provider.
2. Appliance (User) to Application: the applications programming interfaces (APIs) between users and applications.
3. Application to Application: the protocols that an application, service, or system uses to communicate with another application, service, or system.
4. Network to Network: the interfaces among and between network service providers.

CSPP believes that ensuring openness in these interfaces will advance the following critical NII goals:

- To allow users and providers to transmit information smoothly throughout the network.
- To enable wide access by users and providers of information and services.

- To stimulate competitive markets for NII products and services.

The uniqueness of the CSPP report is the detailed attention to the user community. The focus is on how the NII will revolutionize the way individuals will relate to one another by enabling them to work together to access, generate, store, process, transmit, and receive text, data, and images anywhere at any time.

The CSPP model (Figure 2-3), proposed for the national infrastructure, could be adapted to a smaller scale for an academic environment. The same issues of inter-operability between network components would still apply. Another contribution of this model is the focus on the user and the critical interfaces between users and other network components.

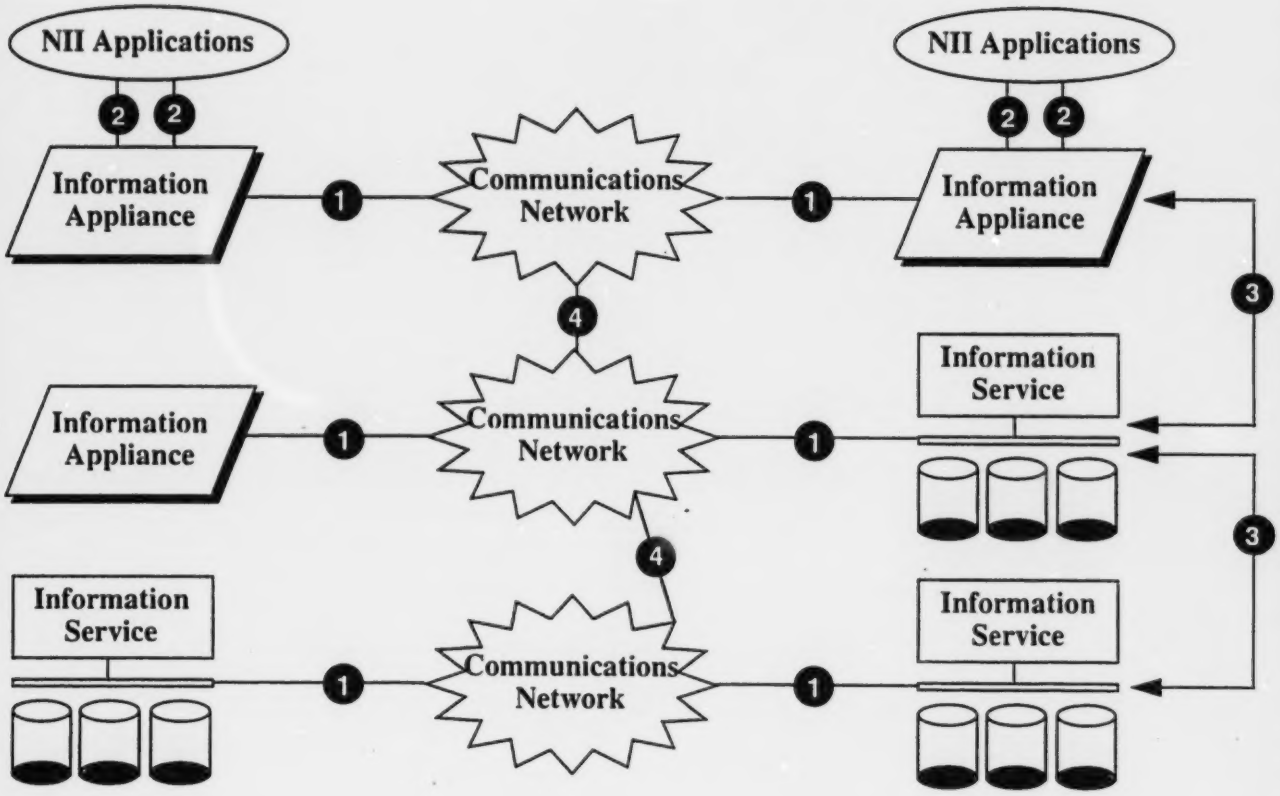
2.4. Review of Existing Data Sources

Although there are few existing models and measures which can be applied to the academic networked environment, there are a number of sources which offer relevant data on academic institutions and IT. Such data may be useful in describing the academic networked environment and in developing measures for academic networks. The major sources of relevant existing data are described below.

General Demographic Data on Universities. The National Center for Education Statistics annually collects statistics on all universities through IPEDS (Integrated Postsecondary Education Data System). There are no variables specifically related to IT in IPEDS. However, several types of demographic data might enter into the computation of performance measures:

- Enrollment in the institution
- Total/full-time students/part-time students
- Students by level (undergraduate/graduate)
- Students by field of study
- Degrees conferred: by level (bachelor's, master's, doctor's); and by field of study
- Composition of staff: total and FTE; and by categories (professional (executive,

FIGURE 2-3. CSPP MODEL



administrative and managerial/Faculty/TA and RA/non faculty professionals); and non-professionals (technical and paraprofessional/clerical and secretarial/skilled crafts/service and maintenance))

- Expenditures per FTE student
- Data on IT in Universities

IT Surveys. A number of surveys concerning the use of IT in academic institutions have been conducted recently by groups such as:

- The Center for Scholarly Technology at the University of Southern California (Fall 1993)
- The American Association of State Colleges and Universities (AASCU) (Spring 1994)
- The Corporation for Public Broadcasting (CPB) (Spring 1994)

Each of these survey instruments is aimed at a slightly different population, all broader than the sample for this study, and has a slightly different purpose and approach. However, there is some overlap between these populations and the sample for this study. Variables specifically pertaining to the networked environment are :

- Issues considered as important in strategic planning
- Type and percentage of on- and off-campus facilities linked to the network
- Services offered on the network (e-mail, library catalog, Campus-Wide Information System (CWIS), file server, etc.)
- Internet access for faculty/staff/students
- Fee policy
- Availability of support and training
- % of student/staff/faculty having access to and using e-mail

Other related variables are

- Number of machines available, by categories of users, type of facility

(cluster/classroom/office), and ownership

- Number of distance-learning courses offered

Most variables measure only availability of services. E-mail seems to be the only kind of service for which there is an attempt to quantify actual use. Very few questions deal with the impacts of IT on teaching and research. Those which do only call for the subjective assessment of the respondent measured on a Likert scale, and are usually phrased in very general terms (for example, "How well has your institution used technology to improve the overall quality of education at your institution?").

USC Faculty Survey on The Role of Information Technology in Instruction and Scholarship. This 1994 survey of faculty in two- and four-year colleges, evaluates use and benefits of IT in teaching and research. Network-related extensiveness indicators are:

- Existence of LAN access, network connections, and modems for computers at home and in the office
- Self-assessment of IT skills, including using online information systems, using e-mail, and using the Internet

Use indicators include:

- Use of Internet services (e-mail to other campuses/databases or library catalog searches/access to government databases/participation in a listserv): never/monthly/weekly/daily
- Network activities since beginning of current term (e-mail to foreign country colleague/e-mail to student/FTP/access materials from another campus/e-mail discussion/felt like receiving too much e-mail): no/once/more than once
- Instructional materials and techniques used for courses taught this term: e-mail to students, materials found via Internet, audio-teleconferencing

Impact indicators include:

- Assessment (on Likert scale) of importance of IT resources: includes access to the

library catalog, access to online information resources, e-mail to colleagues (on campus and to other campuses), access to materials via Internet

- Assessment (on Likert scale) of benefits of IT in the past five years and in next five years in the following areas:
  - Productivity as a teacher
  - Productivity as a researcher
  - Reputation of institution
  - Quality of programs
  - Contact with colleagues
  - Opportunity to work with other departments and campuses
  - Access to information resources

This survey also includes questions related to faculty outputs such as

- Have you, during the past 3 years, received a recognition award for teaching?
- What professional activities have you been engaged in during the past 3 years (# of courses taught, presentations at conference, articles, chapters in books, monographs)?

These output measures may then be correlated with measures of network use.

NACUBO Benchmarking Project. The National Association of Colleges and Universities Business Officers (NACUBO) collects annual benchmarking data on the administrative functions of higher education institutions. Among the 48 research institutions participating in FY 1993, 18 (3 private, 15 public) are in the population for which this study was intended. For the moment, most indicators measure costs and services levels, because these data are more readily available than others. The project covers 36 IT indicators, including five which are specifically related to networking:

- Number of institutional networks
- Networking cost per network connection

- Number of users networked when the current network architecture plan is implemented
- Cost of five- year network architecture plan
- % of faculty, staff and students who are e-mail users

Other indicators deal with IT in general. The most significant ones are:

- Cost per user (total/central IT/decentralized IT; operating/personnel/capital costs)
- Number of training hours per user
- Number of departmental PCs and workstations per staff FTE
- % of students who own their own PCs

CAUSE Institutional Database. CAUSE annually collects statistics on computing services from all its members and maintains a database of this information. CAUSE Data collected in the following areas may be useful in describing the academic networked environment:

- IT management (level of integration of the various computing, information and telecommunication functions)
- IT staffing by function (academic computing/administrative computing/telecom/networking) and type of work (management/ development/operations/user services)
- IT budget by function
- Strategic planning: functions included in IT plans, areas where policies or plans are in place.
- Types of "emerging technologies" implemented or planned

Network related variables are very similar to the ones used in other surveys. But several of them are more specific:

- % of each user group (students, faculty, staff) having access to and using regularly e-mail, gopher, world wide web
- % of institutionally owned academic micros/workstations networked

- % of institutionally owned administrative micros/workstations networked
- Ratio of institutionally owned academic micros/workstations to people in each user group

The section on academic computing uses several indicators to estimate the use of IT in teaching:

- % of faculty making use of software in classroom
- % of faculty making use of multimedia software in classroom
- % of faculty incorporating use of computing in the curriculum
- % of classrooms equipped for computing or multimedia

Summary. All of the data sources included here have some elements which apply to measurement in the academic networked environment. The CAUSE database seems to be the best source of information concerning the following aspects of the networked environment: organization, resources available, and use of theses resources. The USC Faculty Survey is the best source of information concerning the level of use of network resources. And IPEDS provides useful demographic statistics on universities. Other unique contributions from each source include: NACUBO's data on costs, USC's data on participation of each academic field, AASCU's distance learning data, and CPB's impacts of the academic network on the broader community (participation in a community network and access to the institution's resources by outside users). However, none of these instruments measures adequately and comprehensively:

- How well the network performs in term of access (problems of slowness, refused connections etc.), ease of use, success of use
- To what extent specific kinds of network tools and resources are used
- For what specific purposes network tools and resources are used (teaching, research, homework, communication, personal information need, leisure)
- What the impacts on research and teaching performance are.

2.5. Analysis of IT Plans

In addition to reviewing the literature, existing network models, and existing sources of relevant data, the study team examined a group of university computing strategic plans to identify existing approaches and measures associated with the academic networked environment. This analysis supplements the other resources reviewed in that it specifically represents the perspective of academic computing professionals. The research questions which guided this analysis of the strategic plans are as follows:

- What are the components of the academic networked environment?
- What are the impacts, both actual and anticipated, of networking in the academic environment?
- What, if any, evaluation of the academic networked environment is being conducted or planned?

Twenty-one plans were selected, as described below, and a content analysis was performed to identify models and measures, as well as key issues, themes, and concepts. Four criteria were used for selection of the plans:

- The document is for an institution which meets the following criteria: Carnegie Research University I or II, library is a member of ARL
- The document is an actual plan (not a generic description of the planning process)
- The document is recent (published in the 1990s)
- If possible, the document should deal with computing services as a whole (i.e., including academic computing, administrative computing, and network-telecommunications). However, partial plans are acceptable as long as they are not concerned with technical objectives only.

Copies of the plans were obtained from the CAUSE Information Resources Library, and also from participants in focus groups which were held as part of this study. For three institutions, two plans were included, either because they had complementary purposes or because several

years had elapsed between both documents.

The plans varied in length from 7 to 219 pages and they were extremely heterogeneous in content and emphasis. For instance, some plans analyzed the current strengths and weaknesses of the institutions, other did not. Expected impacts were spelled out in some plans but only implied or taken for granted in others. Also, some plans were not comprehensive. Two plans dealt only with administrative computing, two others dealt only with academic computing, and another dealt solely with the campus network.

The initial coding scheme was developed from a content analysis of two plans, then tested with two other plans. The final scheme includes the following major categories:

- Benefits
- Objectives
- Stakeholders
- Resources
- Organizational structure
- User involvement
- Evaluation

This scheme was adjusted during analysis of the 17 remaining plans. Category definitions were refined and a number of subcategories were identified and defined. The complete coding scheme is presented in Appendix A. Definitions and examples for each category and subcategory are presented in Appendix B.

The content analysis of the plans is discussed below, for each of the major categories. identified. This analysis is best seen as a preliminary assessment of the major areas discussed in the various plans.

Benefits. Potential benefits of the networked environment exist in all areas of activity of a university, but to differing degrees. There is a consensus that IT increases research productivity, mainly through increased access to data and increased cooperation. In both cases, this is true

within the institution (e.g., remote access to the library catalog, collaboration between departments) and outside of it (e.g., access to a supercomputing center, searches on remote databases, collaboration with researchers at other institutions). Although it is sometimes difficult to distinguish between them, it seems that benefits to the research process are more emphasized than benefits to the communication of research results (i.e., electronic publishing)

In the administrative area, there is also a consensus on the two main impacts: improved access to institutional data - both by staff and by "end-users" - and increased efficiency of administrative processes. The other aspects noted by some institutions, namely cost reduction, simplification of the organizational structure, and better decision-making, can be seen as consequences of these two primary benefits.

In the area of teaching and learning, there is a greater variety of expected benefits. Richer learning materials, in the form of multi-media and simulations, are mentioned most often. Interestingly, access to databases, which emerges as a major benefit for researchers, is very rarely mentioned as a benefit for students. Two additional benefits, directly linked to the network, are increased communication between students and faculty, and development of distance learning. Other benefits noted by only a few institutions, namely exposure to diversity and preparation for future jobs, are those not directly related to the teaching process, but more to general outcomes of education.

Finally, benefits related to the service mission of the university are mentioned rarely and in a vague way. There seems to be a belief that the networked academic institution can offer better services to its surrounding community, but it is not very clear how.

Objectives. On the whole, the plans are very similar in terms of objectives. Almost all of them include:

- The development of policies, guidelines, and standards, made all the more necessary by the trend toward a distributed environment. In most cases, this seems to be considered only at an internal level. However, a few institutions also discuss

standards and policies at the national level.

- The development of security procedures
- An adequate infrastructure, including interoperability between systems, connection of offices, dorms, classrooms and sometimes homes to the campus network, with a particular emphasis on the equipment of classrooms, and connection to national and international networks
- Adequate user support and user training
- The development or implantation of information servers of different kinds: administrative systems, CWIS, library catalog, bibliographic databases.

There is also agreement among the plans on objectives to encourage the use of IT in teaching. These include: the establishment of faculty rewards such as sabbaticals, grants, copyright fees, and integration of IT aspects into the tenure process; and the formal integration of IT into the curriculum, both by the development of courseware and teaching of IT-related courses as part of a general education core. Fewer institutions identify the encouragement of student purchases of computers as an objective and those that do mention it differ on how this should be addressed.

Some institutions state that every student should have his or her own equipment, and support to public computer clusters is temporary. Other institutions maintain a commitment to public clusters which guarantee universal access whatever the economic means of the students.

Finally, only a handful of universities (all of them state institutions) include a specific objective related to services to the larger community, either through distance learning or through support of a community network. Only two institutions list as an objective the provision of adequate IT tools for disabled students and faculty.

Stakeholders. Students, faculty, staff, and computer services were identified as internal stakeholders in all the plans. External stakeholders identified are primarily of two kinds: private companies and government agencies. Both can be considered either as sources of funding or as

partners in research projects, especially in the area of supercomputing. Often, the two roles are combined. The institutions which include service to the community in their objectives also consider K-12 schools with which they collaborate as stakeholders.

Resources. Not surprisingly, most institutions have very similar concerns in the area of resources. The major concern is a sufficient and stable funding base, which seems in jeopardy at certain institutions. Some plans discuss establishment of a specific student IT fee or new rules for charging departments for services. Other resource concerns include: an adequate, well-trained, and motivated staff, sometimes threatened by competition from the private sector; and continuous purchase and maintenance of adequate hardware and software. Issues related to hardware and software are access to supercomputing resources, either locally or through a regional consortium, and migration from a mainframe to a client/server environment.

Not all plans are concerned with budget requirements and procedures and resource allocations. Those which are focus on the sharing of responsibilities between central computing services and individual departments, a problem which is much more acute in a distributed environment than in a centralized one.

Organizational Structure. The most important issue related to organizational structure is the balance between centralization and decentralization. Migration to a client/server environment leads most institutions to emphasize decentralization. However, many of them also stress the need to maintain a central core, to:

- Support common infrastructure services (network for instance)
- Limit costs (purchase of general site licenses)
- Guarantee interoperability with guidelines and standards
- Coordinate the planning process for IT, and insure its integration into the University-wide planning process
- Provide specialized user support (while day-to-day support is generally seen as a responsibility of individual units).

Interestingly, a good proportion of the plans recognize the need for good coordination with other support services, the library being mentioned most often, especially for the development of information servers.

User Involvement. Most institutions clearly see themselves as "demand-driven" and seem committed to incorporating user needs into their decision processes. Indeed, a few plans devote a full section to a detailed analysis of user groups and their specific needs. However, except for the traditional advisory committees, which often include only faculty, there is no consensus on the best approach to obtain user input. A wide variety of methods are mentioned, including: open campus meetings, evaluation of computing services director by faculty, input from people not familiar with IT, and online user input. Some of these methods, such as surveys and meetings, can provide only periodic input while others, such as online user input and liaisons, can provide data continuously. The establishment of user liaisons in each department is used most often.

Evaluation. Evaluation is clearly not a major concern in most strategic plans. Often, it is not considered at all, or only in very general terms. A few institutions, however, include a section analyzing their current strengths and weaknesses, showing that they do indeed assess their performance. Several plans, however, include a section recommending the implementation of an evaluation process, either in general or focusing on specific aspects, i.e., cost analysis, assessment of new alternatives, effectiveness of IT currently implemented. A few plans include details on possible methods of evaluation, such as:

- Review of policies
- Peer comparison
- Satisfaction surveys
- External reviews
- Assessment by users of the extent to which goals of strategic plans are met

Measures used or suggested are all measures of extensiveness, dealing either with access to network resources or with use of these resources. They include:

- Bandwidth of network backbone
- Connectivity: extent to which all campus locations are connected to network
- User access: extent to which all members of the university community have actual access to the network
- Number of listserv messages per month
- Ratio of computing seats per student
- Number of online transactions in administrative system.

In most instances there is little explanation of how such measures were used or if they were actually implemented.

A few recurrent themes emerge from this analysis. For example, impacts and objectives are:

- Clearly defined and common to all institutions in two areas: research and administrative support
- Well defined but with less consensus in the teaching/learning domain
- Still very vague as far as service to the broader community is concerned, except in a few state universities committed to distance learning and to the support of community networks.

In all areas, the main impacts are always linked in some way with "increased communication" or "increased access to data and computing resources." Both communications and access to data and resources occur within the institution (e.g., cross-departmental collaboration, access to institutional data such as grades, schedules, and financial aid) and with other institutions, academic or not (e.g., collaboration with researchers in other locations, access to remote databases, and electronic submission of grants). The possibility that the academic networked environment might have negative as well as positive impacts is never considered.

Institutions struggle with the necessity of finding a balance between centralization and decentralization as the technology switches to a distributed mode. This affects :

- The development of policies and standards
- Budgeting
- Staffing
- Hardware and software purchase and maintenance
- User training and support

Most of the plans agree that user involvement is necessary in principle. However, except at a few institutions, there are not many formal channels of user input into the development of campus technology, especially as far as students are concerned. Evaluation of technology, applications, or networking is rarely a major concern. There is no consensus on the method of conducting it, and measures used, if any, deal only with extensiveness.

2.6. Summary

Through the various efforts described in this background section, the study team developed a foundation for this investigation. In the process of developing this foundation, the following became evident:

- There are no existing measures of network performance or impacts.
- There is no generally agreed upon model of the academic networked environment
- There are several sources of data on academic institutions, although none of them provides information on network resources, activities, or funding.
- Although many institutions have developed formal plans for network development, the content of those plans varies widely.

Notes to Section 2

1. "An audience is an individual or group that will be using measurement for decision making. A stakeholder is an audience that must buy in to make the measurement program work." (Rubin, 1991c, p. 79)
2. Here one establishes what the different parts of an organization need to do in order to function well.
3. Net interest income, noninterest income, operating expenses, and credit quality.
4. Part of the operating system that manages memory, disk operations, and the file system.
5. The ratio of the output of a process to the input used.

3. METHODOLOGY

3.1. Introduction

Because the focus of this study, assessment of academic networking, is an area in which little previous research has been conducted, the study team adopted an exploratory approach here. That is, the object was to discover and describe the current nature of network assessment and related attitudes, activities, behaviors, and constraints, without reference to a pre-existing research framework. Likewise, the goal was to characterize rather than quantify the variables of interest in this situation. For these reasons, a variety of qualitative methods were used for data collection. They included: focus groups, interviews with individuals, small group discussions, and site visits. In addition, several survey instruments were developed, an expert advisory panel was established to review interim results, and an ongoing electronic discussion group was set up to distribute project updates and to solicit feedback. Interview transcripts and notes from observations and discussions were analyzed by content analysis. An overview of the methodology which was followed in this study is presented in this section, and details concerning the application of each individual data collection and analysis method are presented in the Results and Discussion section (4.).

3.2. Data Collection and Analysis

The collection and analysis of data for this study was done in an iterative fashion. That is, the data collected in one stage were analyzed and used to inform the data collection in the next stage. Following is a brief summary of data collection activities.

- A focus group of academic computing administrators and staff from a selected university was conducted to explore the study topic.
- A second focus group and a small group interview were conducted at a national meeting of individuals involved in academic computing.

- Results from the first two focus groups were presented at a conference of academic computing professionals and feedback was solicited via a small group discussion following the presentation.
- The study team then made site visits to two academic institutions in order to explore in depth the issues which emerged from the earlier focus groups, interviews, and discussions.
- Once the data from the site visits were analyzed, preliminary conclusions from the research up to that point were tested, and issues were further investigated, in a focus group of individuals from the same university where the initial focus group was conducted.
- Final results were presented at another national conference of individuals involved in academic computing and feedback from the audience was solicited.
- A final focus group was conducted at the conference where the results were presented.

Additionally, the study team conducted an ongoing electronic discussion among interested individuals concerning the interim results of the investigation. Feedback from the discussion group was incorporated into the evolving methodology. Also, periodic reports from the investigation were submitted to an expert advisory panel which also provided feedback which was incorporated into the evolving methodology.

3.3. Population and Sample

The population of interest in this study includes colleges and universities which are actively involved in the development and provision of networked resources and services on their campuses and the connection of their institutions to entities outside of their campuses via the Internet. Initial criteria for sample selection were: the institutions selected had to form a homogeneous group in terms of main institutional characteristics and mission; and each had to have an academic network

already highly developed and in use. These two criteria were met by focusing the study on research universities, as defined by the Carnegie Foundation for the Advancement of Teaching. The foundation classifies all higher education institutions in the U.S. according to two main criteria: the range and number of degrees offered and the comprehensiveness of the institution's mission. In the Carnegie classification, Research Universities are grouped in two categories :

- Research Universities I are those which: offer a full range of baccalaureate programs, are committed to graduate education through the doctorate, place a high priority on research, grant 50 or more doctoral degrees each year, and receive $40M or more in federal support. In 1994, there were 88 institutions in this category.
- Research Universities II are those which have the same characteristics as above, with one exception: they receive less federal support (from $15.5 to $40M). In 1994 there were 37 institutions in this category.

The sample was further narrowed by limiting it to Research Universities I and II which were members of ARL. ARL has 119 members, of which 109 are university libraries (including 13 from Canada). New members are admitted by invitation, and membership is open to major university libraries whose collections and services are broadly based and to certain other libraries whose collections are recognized as having national significance. Since ARL tends to be involved in issues related to networking, especially through its participation in CNI, membership in this association was determined to be an indicator that an institution has interests and experience relevant to this study.

Of the 125 Carnegie Research Universities I and II, 87 are members of ARL. Seventy-one are classified as Research I, and 16 as Research II. It is these 87 institutions for which the results of this investigation will be relevant. Individuals who participated in this study, as focus group members, interviewees, and advisors, were affiliated with institutions which are among this group of 87, although not every institution is this group is represented.

4. RESULTS AND DISCUSSION

4.1. Introduction

Results from the various data collection and analysis activities are presented here in chronological order, thus demonstrating the evolution of the project as one stage of data collection and analysis informed the next. The project began with two focus groups and a small group interview to collect data on the current state of academic networking and assessment. Following these initial data collection activities, a small group discussion was conducted to review preliminary project findings. The study team then made site visits to two institutions where we conducted interviews with individuals and small groups. Another focus group was held, feedback was collected after a conference presentation, and a final focus group was conducted.

4.2. Initial Focus Groups

As shown in the preceding review of the literature, there are few examples of models of the academic networked environment and few reports of attempts to identify measures of the impacts of networking on academic institutions. This being the case, the first step was to do an empirical assessment of the current state of academic networking. This was done via focus groups at two different locations. The information gathered in these focus groups would then be used to guide the collection of data during the site visits. Anticipated outcomes of the focus groups included:

- Identify major issues in academic networking and existing evaluation methodologies and measures of impacts of academic networking.
- Obtain insight into the decision processes associated with the implementation of network technologies and services.
- Identify the groups involved in, or having an influence on, those processes.
- Identify existing models of the academic networked environment.
- Validate the findings from the literature review which indicated a very sparse amount of information on the topic.

- Generate views and perspectives that would be useful to the study team in terms of (1) developing a model of the academic networked environment, and (2) developing measures to assess this networking environment.
- Inform the future development of the project's methodology.

These focus groups generated extremely useful information that helped define project activities and suggest strategies for accomplishing broader project goals.

The first focus group was held at a major private university in the northeast on November 21, 1994, and included members of the school's computing services group. The study team designed the focus group primarily as a pretest for a later focus group, but the results from the pretest were very valuable and have been incorporated as part of the project findings.

The study team conducted the second focus group, as well as a small group interview, at the 1994 Fall Meeting of CNI in Orlando, Florida. (The study team originally planned to conduct two focus group sessions at CNI, but due to scheduling conflicts with other conference activities, one session was attended by only two participants. Thus, the study team conducted the session as a small-group interview.) This conference was especially appropriate for the data collection activities as members comprise three key groups of interest to the study: CAUSE (academic computing professionals), EDUCOM (higher education technology professionals), and ARL (academic research library professionals).

In both locations the study team followed standard methodological procedures for identifying participants and conducting the focus group sessions (Krueger, 1988). Selection of the university participants was based on criteria that included: knowledge of the university network, experience in either developing or managing that network, and an interest in participating in the focus group. Criteria used for the selection of the CNI participants included: upper-level university managers responsible for administering the network at their institutions; familiarity with national networking issues; interest in the measurement and evaluation of networked services; and ability to attend the CNI conference.

For all sessions, the study team prepared a set of questions to guide the discussions. The topics covered in the university session (see Appendix C) informed the topics that the study team selected for use at the Orlando sessions (see Appendix D). At all sessions, a study team member distributed questionnaires that requested demographic and other background information (see Appendix E).

Transcripts and notes from the focus groups were content analyzed to identify key issues. The research team members who acted as moderators analyzed the transcripts independently and summarized the notes taken. The summaries were compared and are integrated in this report. The following sections provide a summary of the issues discussed at the university focus group session and the CNI sessions, and conclude with an analysis of the responses to the questionnaires completed by participants in all the sessions.

4.2.1. University Computing Focus Group

Seven employees from the university's academic computing services (ACS) group participated in the focus group, which lasted approximately two hours. The key issues which emerged during this session were:

The Network as a Utility. The participants saw the network as a utility such as central heating or the telephone. One participant used the analogy, "We are like plumbers: water or bits, must go through the pipes or wires. Plumbing is the same as wiring, but our systems are more complex." This view, that the system is the same as heat and electricity, makes it unnecessary to justify the existence of the network.

"We believe in the technology, and believe that the outcome is positive. This is accepted technology. You don't ask questions, just use it, like telephone service." This analogy removes responsibility by these professionals for ensuring that the network is used efficiently. Just as there is little concern for how the telephone is used, unless illegally, the participants are not overly concerned with the lack of training among users.

Evaluation. To the participants' knowledge, there are no formal processes to evaluate the network. Their definition of a good system is one with seamless integration, "the less you notice the network, the better it's running. If you cutoff the network for one day, the users will see its impact." An invisible system does not generate much feedback. The participants are not aware of the user's needs. "We don't know what the faculty does, or how they use the system, unless it crashes and burns."

When pushed to answer how to judge the efficacy of the network, they discussed system standards, such as the amount of time the system is running, or meeting the manufacturer's standards for the ethernet. "We can predict how often the system is up, it's somewhere in the 99.9% range, but that doesn't mean that people are using the system successfully. The user doesn't care that the reason they can't use the system is user error."

Daily reports are compiled listing the busiest networks, saturation times, and user complaints. However, these reports are not categorized or kept. To these participants, reliability is the main issue to evaluating a network.

The participants acknowledge informal peer evaluations. They are very aware that the university must stay technologically competitive. The marketing research recruitment data showed that students do not base their decision to attend this university on its information infrastructure. However, if the university was not technologically competitive, recruitment would be affected. Benchmarking against peer institutions or "keeping up with the Joneses" appears to be the most effective method used by these participants to evaluate the network. These informal comparisons are performed by different stakeholders within computing services: "The higher up in the hierarchy, the more the comparison is of the overall system. The lower in the hierarchy, the more one is interested in the nuts and bolts."

User Involvement. When the participants discussed the user, they usually meant faculty members. When asked who is responsible for assessing the impact of the network at the university, the participants answered that the faculty and the deans are. Although the faculty is

responsible for assessing the impact, the participants freely acknowledge that the faculty is poorly trained to do that. Another problem that they perceive is the unrealistic expectation of the faculty that they can use the system efficiently with no time investment.

As the plumbers, their responsibility is to build and maintain the system. They don't know how the system is being used, unless the system fails. When the system fails, they receive user input in the form of complaints. The participants state that only the faculty and the deans know if the system is being used effectively.

The information infrastructure is partially demand-driven. There are some services which must be updated or changed because of user overload. There are also some services which the user is comfortable using and is resistant to changing.

It is very difficult for faculty with only a basic knowledge to assess the impact of the network. The faculty have different accesses to the network, some have ethernet connections, while others have dial-up connections in a central location. Some departments are heavy users of the technology, while others are not. Faculty are not uniform in their use or knowledge of the technology which is available. Simply stated, the faculty is not in a position to assess the impact of the network on the academic environment.

Vendors. The information infrastructure is partially vision-driven. It would appear that vendors should attempt to supply the vision by promising applications, impacts and outcomes linked to their product. However, very few vendors are interested in the university market, focusing instead on corporations. The technology is so state-of-the art, that the vendors are not sophisticated enough to promise impacts. They have difficulty thinking of applications. From the perspective of the participants, vendors believe that their product should be purchased because the technology is good.

In addition to these key issues, the focus group participants identified the following barriers which limit them in building a better networked environment:

User Training and Computer Literacy. User training and computer literacy barriers focused

on faculty. There is no accurate way to measure computer literacy. Some participants suggested self-evaluation surveys and tests to determine computer literacy. It is important to train the faculty, as they will set the tone on campus and the systems will be used efficiently and effectively.

Budget. In these times of decreased enrollment, decreased federal and state funding, and down sizing, budgets are being slashed. Investing and maintaining information technology is very expensive. There are times when the users expect ACS to be venture capitalists. The participants are uncomfortable in this role. If the departments are unwilling to make the technology investment, then ACS does not want to invest either. As budget increases become more competitive, the need to justify expenditures will become critical.

Fundamental Changes Without Disruption and Interoperability. One of the fundamental goals of ACS is seamless integration, therefore, it is very difficult to make any changes to the system without disrupting the network. These disruptions must be made at times of limited user access in order to maintain the appearance of transparency. When planning changes or expenditures, it is important that all the systems function together.

Human Resources. One participant stated that "human resources are a bigger obstacle than budget constraints." It is difficult to attract and keep a staff with the expertise and devotion to maintain the system. It is also necessary to have a staff who can be both demand- and vision-driven.

Space and Distributed Nature of ACS. The participants felt that space was a problem because ACS is in nine different locations on campus. They would like a centralized space, in order to be involved in the every day decisions of ACS.

Impact Assessment. When the moderator asked what types of statistics could be gathered to assess the impact of the network, the participants quickly listed the following:

- e-mail traffic
- the number of local listservs and participation
- cluster utilization

- the number of courses with a computer component
- dial-in statistics
- the number of network connections
- the number of times that CWIS is accessed
- and the timeliness of CWIS.

A key theme in this session was the difficulty in separating the Internet/NREN from the Campus-Wide Information System (CWIS), or other networking services. The seamless integration of the network has made the system transparent, and the user may not know whether he has accessed the campus system or the Internet. The parameters of this study were broadened at this point, because the participants demonstrated that the system is ubiquitous.

Another key finding was that there are no impact measures gathered by these computing professionals, and that these participants did not think that impact measures were needed. However, in discussions about budget limitations, they acknowledged that justifying the impacts would help justify expenditures.

4.2.2. CNI Focus Groups

Twelve academic computing professionals participated in the CNI focus group and small-group interview. The key issues which emerged during these CNI data collection efforts are presented here in three major categories:

- Drivers of the development of network technologies and services
- Barriers to the development of network technologies and services
- Measures of the effects and impacts of network technologies and services.

To a certain extent, these categories are products of the questions asked. For example, participants identified measures of the impacts of networking because they were asked how they evaluated their networking functions and whether their networks were adequate for the needs of their institutions. However, many of the subcategories described below, such as measures of input and measures of

output, emerged directly from participants' comments. Also, the moderators encouraged participants to share their definitions of terms used in the questions. For example, the moderators did not give participants a definition of adequacy but rather asked participants to explain how they measured the adequacy of their networks. Participants' definitions emerged from those explanations.

Drivers of Network Development. All of the CNI participants were from institutions where the demand for networking capabilities is growing. They identified a number of forces, discussed below, which appear to be fueling this growing demand.

Participants identified two major classes of users—faculty and students—and discussed characteristics, expectations and needs of each class. Participants saw user demand for services and dissatisfaction with existing services as primary drivers of networking development. Participants perceived that a certain level of networking capability, which they couldn't define further, is essential to support faculty activities, especially those activities involving collaboration.

> For research universities, a driving factor in getting the network is that the scientific and engineering communities can't do business without the network....A physics department, for example, would rebel today if they didn't have a high bandwidth connection to the global network. I mean they would be out of business. They communicate constantly with people at...Fermi lab and CERN...their peers around the world....For research universities, pretty much it's not an option.

In addition to collaborating on research projects, faculty are increasingly collaborating on applications for research funding, and need networking capabilities to do so.

> Researchers at the university are not capable of competing for grants without this kind of access....[we] are sort of routinely team responding with one or more institutions. The cost of research devices being such that oftentimes universities will pool their resources when they respond to an NSF grant request, or something like that. Clearly they wouldn't be able to do it without that [without networking], so they would just start losing grants at a

high rate of speed.

For certain kinds of institutions, specifically small and geographically remote institutions, networking may be essential to their survival. "The faculty argues that, since they are so resource poor at their institution, the only way in which they can...get access to resources that will upgrade the quality of the little institution is a good networking infrastructure." Thus, it is not at just large, research institutions where networking is needed.

At times, it is not user demand that network providers listen to but rather, what one participant described as, "A low-level, or not very high priority, but a reasonable volume, buzz of dissatisfaction." This might be manifested in complaints about overcrowding on the network or the inability to perform certain functions or access certain information sources. User dissatisfaction then provides the impetus to expand or improve services and support.

User demand, from both faculty and students, now seems to be based on increasing expectations that networking should, and will, be available. Whereas there was a time when network administrators had to actively publicize the availability of their services, there was agreement among participants that such is no longer the case. "For a long time we were both putting in infrastructure and evangelizing the concept of networked services....we don't have to evangelize anymore." In fact, the heightened expectations of users have been instrumental in causing network providers to accelerate their planning and implementation schedules. This was particularly true in the case of incoming freshmen.

> Seeing a whole new crop of freshmen come in, computer literate in a way that we had never seen before...all of a sudden this class came in and said, 'This is our god given right and why isn't there a connection in every dorm room?' We had a plan to have that in a year and a half, and we...have just spent the last two months wildly coming up with a plan to make sure that we got it by September, 1995, because student demand is there.

In addition to the increased level of demand for network access from on-campus facilities, there is a growing demand for access from off campus.

> Home access is really what did us in in the last six months...it was always something hovering there as sort of a problem but it was always contained. Something happened over the past six to twelve months where it's just not adequate anymore to have this available to people in the office. They absolutely need it now at home, in much bigger numbers and much higher bandwidth than they ever did before.

Thus, growing interest among faculty in collaboration, increasing demands from students for dorm access, and from faculty for home access, all are contributing to the development of network technologies and services.

New technologies, including hardware and software, also drive the development of networking. The impetus to implement these new technologies comes from both users and computing services staff. In part, the demand among users for network access has been driven by the availability of information and applications online. For example, "The course and teacher evaluations...used to be printed and then they decided to stop printing and put it online. And that has worked well. It has also driven demand for access..."

Also, institutions are faced with keeping up with changes in the industry, changes which users—faculty and students—are aware of and want. One participant spoke of faculty awareness of client/server computing and how that affected plans for replacing mainframe computers.

> You have a political correctness problem, because in a lot of institutions, buying another mainframe or upgrading it is not...if the institution is going to buy a new mainframe [people believe] that there is something...there must be something terribly wrong with the administrative group or central computing group.

However, computing professionals added that they do not rely on users to request new technologies or services. As professionals, they feel responsible for monitoring the market and selecting appropriate new technologies for their users.

> You definitely talk to people who have work to do and [ask] what they think their work is going to be like in a couple of years....but I guess the thing I would be careful about is that

> if you talk to someone about what they wish they could do and they tell you...I don't know how to put this, but it's almost too late. You almost haven't done your job if you can't anticipate that from a technical standpoint.

They also select new technologies to replace older ones which are outmoded, cannot support user demands, or cannot be maintained efficiently.

> A lot of it is dictated by antiquated systems that are, that have been, outstripped by federal regulations. And you are basically staring at the option of taking something that was written, you know, fifteen years ago and patched ever since, and having to do a complete overhaul...or pitching the whole thing....the stuff was written in four different languages and so when you get beyond the ability to hire people who understand...COBOL or PL/1 or whatever these things were written in you have a hugely labor intensive maintenance problem...

The aging of technologies, as well as the availability of, and demand for, improved technologies, combine to drive the development of campus networks.

Institutional support for networking may also be driving its development. Participants agreed that there seems to be an emerging consensus among top administrators, at least at their institutions, that incoming students will expect a high level of network capability and support and that their institutions must provide this in order to remain competitive.

> In planning for our network, we put together a requirement that all the buildings had to be interconnected. And we gave the president an option of putting networks in all the dormitories. And he basically came back and said without that option he wouldn't approve the plan. He wanted the whole thing....undergraduate education was the driving force for the whole process.

In addition to providing network capabilities and support for students, there is a recognition among university administrators that a network is essential in order to attract good faculty. As one participant explained, quoting a university provost, "The world is now very different and every

faculty person we recruit needs a dowry, needs to understand what kind of workstation they are going to have on their desk, what kind of networking connection."

In fact, at some institutions, and in some disciplines, network technologies and services may no longer be viewed as an added inducement to attract faculty members. Rather, they have come to be viewed as minimum requirements.

> I think that five or six, or even more, years ago—and I'd like to say that we were an early adopter in networking—it was an attraction. Now it is a god given right. There is an expectation that it will be there and it will be available 24 hours a day, seven days a week, absolutely reliable, bandwidth unlimited, and at absolutely no direct cost. That's expected....To the extent that you do not have what is expected and what is the ideal, it is a detriment. I don't think anymore that it is a big attraction. It's an expectation.

Many faculty now view networking as an essential function on campus. And administrators share that view.

> It's like a good library. If you are going to be a major research university, and you want to attract and keep the best faculty, you just need to have that infrastructure....This is true in the sciences, somewhat true in the social sciences, and now becoming true even in the humanities.

In this changing perception of the infrastructure and the elements which comprise it, networking often is considered another utility.

> There is an analogy in telephony. Is there not a god given right to a dial tone? Could we expect to recruit a young, hot shot assistant professor and say, "You get a desk, you get a part of the secretary, you get lights, but you don't get a telephone?"

Thus a certain level of network development is perceived to be essential to the functioning of the university. In addition, universities may be recognizing that computer literacy and network literacy are critical elements of an education designed to prepare students to function in an information society.

> [The administrators] accept the fact that if they don't equip their undergraduate students with knowledge of technology that these people will be shortchanged as they go out into the world and compete with other students for jobs and careers. It has become so ubiquitous a part of the corporate job structure that institutions now recognize that they have to provide this sort of infrastructure....I think that's why a lot of presidents are willing to make the investment. They talk to the people on their board, they talk to business people, they talk to students, and they realize that this is the way the world is moving, and if they don't move that way too...they'll be left behind.

Additionally, participants viewed network technology as essential to preparing students to go into a work world where collaboration and cooperation are important. Students are "understanding how to put groups together and work together collaboratively over this stuff. That's something that's another dimension that I'm sure we're teaching them. But I'm not sure how to measure that."

Participants also identified "the convulsion that is happening in collaborative research and collaborative education" as another factor driving the development of networking capabilities. Participants described

> ...students who are up at four in the morning using the network because the old model, the old Socratic model, of one instructor and fifty students is no longer operative...Fundamentally this is changing the way teaching and research are being done. Thereby what we are doing is wholly inadequate in and of itself.

In summary, participants viewed the changes in the types and levels of support required by faculty and students as contributing factors in the development of network technologies and services.

Barriers to Network Development. In spite of the increasing demand for networking among some groups and growing recognition on the part of administrators of the importance of networking, a number of barriers to the growth and development of networking exist. Barriers participants identified include: uneven growth in user demand; problems associated with network

technologies; and institutional limitations, both financial and pedagogical.

Participants identified growing user demand as a driver of network development. However, they also identified the nature of that growth, and their inability to predict timing and patterns of growth, as barriers to network development.

> Something that we have heard over and over here, but it is indeed a barrier to us providing, in a timely manner, the services we think we should, is the very lumpy demand curve....Because what happens is...there is a pent up demand that wells up...until all of a sudden there is this crushing demand. Then there's the giant push....The resources become available...but now it's a panic. Now it's in response to this overwhelming pent up burst.

Another negative aspect of the growing awareness among users of networking is the problem of misinformation. While users are more knowledgeable about technological developments, their understanding can be somewhat shallow. "[The hype] raises a lot of expectations and it also raises a lot of fears. A lot of what you read about in the press about cyberspace is somewhat negative and causes a lot of interesting...knee jerk policy discussions as well."

In spite of this growing user demand, there are still many members of the academic community who fear and avoid the technology.

> Anybody who has been at a university for ten years or longer...can be assumed to be relatively technophobic....[for] the incumbents, it's a very large training and education program that we have to put in place...to essentially pull the bulk of the existing staff up to a level of competence where they are actually going to be able to make, on a day to day basis, effective use of anything you put on their desk, from a GUI interface for purchasing all the way to monitoring news groups on the Internet that are relevant to their particular discipline or function....it takes a lot of work to get people to a level where they can deal with this stuff.

Providers of network technologies and services must educate and train both the technophobic groups and the groups that are clamoring for the latest, although possibly inappropriate, technologies.

But fear is not the only reason people do not take advantage of the technology. Deficiencies in the technology itself may be responsible for some low levels of use and lack of support for further development. A major challenge, to network managers, is

> ...getting our systems to be easy to use. They're still not good enough. They're not like dialing a telephone to get what you need...the systems are not intuitive and easy to use. And there are a trillion different kinds of systems and almost a trillion different interfaces to access them...the systems are getting more complex as we put more and more information services up.

And as the technology becomes increasingly complicated, the provision of support and maintenance becomes more challenging. "Dealing with the networked environment, where you have many places to fix and go wrong, is much more complicated than word processing on standalone computers hooked up to a printer."

Another aspect of the network technology which stands in the way of development is its distributed nature and the problems that creates.

> It's the management of this distributed structure. Anyone can get an Internet address and hang a server on the network. And if they don't manage it properly and start any password that comes through that server, your whole network is exposed. There are a whole lot of issues that the mainframe administrator used to handle. It's now distributed all over the network. We used to have a mainframe mail system, and if the system was abused, we had people who would go out to talk to the people who abused it and try to educate them in the proper use. Now you've got mail systems all over the campus, and who's responsible for seeing that system administrators pay attention to these kinds of things? It's a whole raft of management issues we took for granted in the mainframe, which we haven't even

begun to think about how to do.

Yet another barrier to the development of networking is the lag between user needs and the availability of the technology to meet those needs.

> We are trying to figure out how to deliver broadband that integrates voice, data, telemetry, video. And I think right now a major problem for us is that we are at a kind of a crossroads. We're not there yet. And so you are forced with investment decisions on what you believe is older technology, but the new technology is not quite in place yet....at least in terms of commercially available production services or services that you can out into production. They are not quite there yet.

And it's not only the hardware and software, but the information resources as well which may lag behind demand. Participants saw themselves as

> ...being somewhat at the mercy of what services are available....we buy just about anything that will become available or any network service that is available that is appropriate to our collection development policy. We try to twist vendors' arms about what's available. But if you look at our offerings in terms of information services, library collection kinds of things, it's very much dictated by what's in fact on the market.

And, on occasions, technology developments, and the sudden awareness and demand for new technologies, take computing professionals by surprise. "The emerging technologies are moving quickly....all of a sudden new technology becomes available that puts an incredible...it's the old story of everybody flushing during half-time during the Super Bowl. We have to cope with that."

Finally, part of responding to the demand for home access, as described above, is what participants referred to variously as "the last mile problem," or the problem of "the small pipe to the outside world." However, participants believe that they can't solve the problem themselves. The solution will require them to work together with groups outside their institutions, like utility companies, including power, cable, and satellite providers, as well as vendors of technology,

services, and resources.

Other barriers to the development of networking include the lack of appropriate models for teaching in a networked environment, inadequate user support, and limited financial resources.

While the new network capabilities enable new approaches to educational processes, there are few models of how to use the capabilities. "Another barrier, then, is pedagogical models that take advantage of the technology...people are fundamentally automating old things...most of our professors haven't really internalized how to use the technology to really change the way they conduct their classes."

In addition to providing new technology, there is the task of providing training and support to users of the new technology.

> We're talking here about retooling and retraining the staff as well as users....There are significant management issues as well. Structuring and organizing and that sort of thing. Now you suddenly need a world class help desk like they have in big companies, in industry, that we never needed before. First class network engineers to deal with bottlenecks in traffic...you've got to change your organizational structures to deal with this."

Changing those structures as well as adapting the physical facilities to accommodate the new technology require financial resources which many institutions simply don't have.

> We simply can't get the financial resources to solve the problems that [we] understand. We have 500 classrooms, and they are averaging 30 years old, and in order for you to teach in the classroom using a computer and projection system, you need to have new shades, new acoustics, new this, new that, and at an average cost of a couple million dollars per classroom, or whatever it is. Pretty straightforward way to solve that problem: it takes money, and there is not enough money, and you just have to slog it out.

This lack of resources to buy the technology, along with a lack of appropriate models to apply the

technology, represent barriers to the continued development of networking on campuses.

Measures. A final issue which was considered during the focus groups was that of measures of the impacts of networking. Participants discussed financial measures, adequacy measures, and impact measures and agreed that while traditional measures of technology impacts are often inappropriate, new measures have yet to be developed.

Participants agreed that financial analyses of the costs and benefits of technology may be inappropriate to networking "All of the traditional models, all of the accounting models, just don't apply anymore....[we need] to develop new models, and these models are going to be squishier."

Approaches to measurement which focus on ROI (Return on Investment) have, so far, revealed few financial benefits associated with investment in networking. "The one thing I know is that we haven't lowered costs. And some people look to [networking] to lower costs. And I think that is probably a holy grail that I don't know how to get to."

However, participants also agreed that they experienced very little pressure to show cost reductions and financial returns on investment. There was some suggestion that academic administrators do not ask for economic justification of requests for investment in new technologies, or in other improvements to the institution.

> Colleges and universities don't make these decisions based on direct economic issues. They don't ask what is the cost benefit....they don't ask that with respect to anything they do. I mean there is no bottom line, there isn't....in a corporation there is a balance sheet with the technology input and the labor input and the cost of the product and its competitiveness are all evaluated. And whether you can afford to upgrade the technology is a matter that is determined by whether you can pass the cost off to the product that you are producing. That never happens in higher education....It's totally not an economic model.

Although, for capital dollars, there were instances where economic justification was required.

> Nobody is throwing capital dollars at networking [at our institution]...they are expecting to

see some sort of supporting improvement, or some sort of recovery scheme to come back to recover the capital costs. It's a business improvement....In the case of undergraduate access, we basically advocated direct recovery from the students...assessing a technology fee...to defray a combination of the capital and operating costs.

In other instances university administrators were reluctant to assess fees from students or faculty to cover the cost of network access.

We have this plan of scaling up home access through a recharge plan...and create a new service just for faculty...and the vice chancellor bought it and he said, "But I just don't want to charge the faculty." It was very much that issue of if something is this important to this constituency, we're going to find a way to do this.

Likewise, another university attempted to provide network access to dorms without charging students. "Because of student demand, and the surge of interest in student services...the university budget office is sitting around right now figuring out how to reallocate capital funding for this, because this is just so important."

Often there are financial tradeoffs that have to be made in order to support expanded network services in institutions which do not have unlimited financial resources.

Because we're certainly not immune from all the cost cutting measures going on throughout the rest of the institution...we've got to make arguments and internal kinds of decisions on trading some things off...but I've never been asked to justify the marginal value of a particular set of ports in a place on economic terms.

Computing administrators sometimes justify an investment to improve networking capabilities by demonstrating that money can be saved by the investment.

The other thing that was demonstrated when the university first put in its Internet connection was that instead of having to buy a supercomputer in order for the physics department to be able to do what was considered cutting edge work, all they needed was a 56 kilobit line to [another university]. And that made them competitive in the grant area.

> So it's arguments like that that could carry substantial weight, when you can show the defraying of some major investment....because they could make use of supercomputer centers elsewhere...

Another facet of measurement has to do with whether the network is adequate to meet the needs of users. One measure of this adequacy is universal connectivity.

> Essentially every member of the university community has the ability, the physical, technical ability, to connect to the networked resources of the institution....the university has just invested several million dollars to bring a backbone network to every building in the institution with the object of ....having every workstation connected to the backbone network....As well, the university just finished investing in putting an Ethernet port to every student in the dormitories....So every room has one port per student in that room....the community, the students, faculty, staff, administrative community has the technical access...I would say that is an adequate environment.

Participants suggested several quantitative measures of adequacy. "Certainly one measure of adequacy is how many desks you reach....Another measure is certainly what bandwidth and what capacity you are giving them." And there was agreement that there are some basic technological requirements that would have to be included in any definition of adequacy. "Today, because of high bandwidth requirements of multimedia, an institution has to have, first of all, an adequate LAN infrastructure with adequate bandwidth."

But the definition of adequacy may not necessarily extend to actual use of the technology and services. Whether departments or other units in the university choose to take advantage of the technology is another issue. "The urgency with which a given department makes the investment to make the connection can vary from one discipline or function to another."

Another measure of the adequacy of the networked environment is related to support of the technology described above.

> The second important element is support infrastructure, the size of the networking group

> and the user support for all of the problems that people have. If the support organizations don't have the manpower or the knowledge or whatever, then you are going to have problems.

Also, the ability of individual departments to manage their own networked information resources was considered an indicator of adequacy. "Adequately preparing departments to build their own and mount their own information...we can at least count that and judge whether that is adequate in some sense."

Another facet of measurement has to do with the information resources available via the technology. "It's not just the wires into the place, it's certainly what resources they get....The most common network resources are the library, most institutions that have a network have connected the library...and a large number of institutions have...campus-wide information."

Beyond the measures described above there was agreement that there is another, broader measure of the network's capacity to meet users' needs.

> It's not sufficient to talk about bandwidth and connectivity....you've really got to talk about all the services and capabilities which reside on the network. It seems to me, if you are asking questions of adequacy, you have to ask the questions about are the services which assist the individual in doing whatever it is that they are going to do.

Moving beyond financial measures and adequacy measures, participants discussed a developing interest in measures of the impacts of networking on teaching and learning. Administrators are beginning to ask questions like, "Has it enabled an instructor to increase the contents or broaden the contents or get deeper in the content of the class?" and "Has it reduced their administrative work in administering the class?"

In response to such questions, network administrators are beginning to develop and apply new measures. For example, "We provided multimedia support for a classroom [and] we have evidence that the faculty member [using the classroom] is spending less time on the mechanics and more on the content. So that the students are getting more content and learning it faster." In a

similar case, another participant commented on faculty members spending less time writing on the blackboard, or photocopying and distributing materials to students, when the information was made available over the network.

Another participant reported on a study done to determine if students believed that their use of electronic information services affected their work or their grades. "Again, you know, it's still soft in the sense that they are asking users their view, not that there's an external quantitative measure. But there is an effort at that kind of measurement." However, most evidence of networking's impacts on teaching and learning is anecdotal.

> It's a faculty member saying, "We've got an architecture class, and we're doing shared design projects with students in Norway." Another faculty member saying "I have a small class and there's another fellow in Nebraska with a small class, and we are collaborating using the Internet." Another faculty member is saying, "I tried some things with computer mediated communication to get everybody to join the discussion and I tell them that their grade will be based on their level of participation in an online discussion. I have more consistent participation by every student in the class than I ever had in a real classroom." There are all kinds of things like that that you can point to that you can say that those are things that could not have happened any other way. So those are tangible outcomes but you can't measure them. You can't say, "Did they get a better grade?" "Did it attract a whole new class of clients?" It's hard to quantify.

Another problem identified in trying to create measures of the impacts of networking on activities like teaching and learning is the lack of good measures of these activities, regardless of networking, and the lack of existing data on teaching and learning in a non networked environment at some institutions. As one participant cautioned,

> I think that a major problem you are going to run into early on is that we never really measured these outcome measures or evaluated the quality of instruction or learning or anything anyway. So now we are asking how has this proved something that we never

measured anyway.

Participants also reported on their efforts to develop measures of networking's impact on research. One person described a study in which he compared the number and value of research grants received by faculty who were active users of the network to those received by faculty who were not active network users.

> There was an amazing correlation....between those that had the network connection and substantially higher amounts of research dollars that came in....I did it within humanities, I did it within hard sciences and did it within engineering, did it within medicine...it was there, it was indisputably there. [But] there are probably a lot of intervening variables."

Other measures of networking's impact on administrative processes also are emerging.

> The largest dividend that I think you'll ultimately be able to point to is some sort of reduction in paperwork. And some sort of reduction in lead times, to be able to reengineer processes and adjust the university's work to some new, speedier way of doing work electronically.

But the impact of networking goes beyond reducing effort and speeding up work processes. "It's not just improving what we're doing. It is totally enabling us to do different things that we couldn't do before....so it's not just doing what we have done and doing it faster and better and more efficiently." For example, networking may be a factor in changing the market for higher education.

> I think in this next (state) legislative session...we will see the legislature require us to permit high school students to have simultaneous registration in college courses in high school. And we couldn't do it without the network. I mean the legislature couldn't even think of that.

Although there are examples of the impacts of networking, as described above, measurement of these impacts remains very difficult. As one participant described the situation, "We are at a very immature stage where we really, I think, are only getting glimpses of what the

future is going to hold. And so, it's going to be very hard, I'd say, to measure things, because it's very foggy just where all this is going to go."

The development of networks at academic institutions is in a period of rapid growth, fueled by user demand, the emergence of new technologies, and institutional support. There seems to be little doubt that networking is becoming crucial to student learning, faculty teaching and research, and institutional survival.

However, barriers to the continued development of networking remain. It is difficult for academic computing departments to anticipate and support user demands. And the technologies, services, and information resources users want and need are not always available and, when they are available, they're not always easy to access and use.

In spite of these barriers, there is evidence that networks are having impacts on people who use them and on the institutions in which they work. Quantitative, empirical evidence of these impacts is rare. Yet there is anecdotal evidence as well as an intuitive feeling among academic computing professionals, that access to network technologies and services is changing and improving the ways in which academic processes are conducted.

A final issue which focus group participants considered was the development of a model of the academic networked environment. They agreed that there are many elements of the environment which are consistent across institutions. "If you look at this in detail...it is remarkably consistent across institutions....people [aren't] creating different academic networks." "There is a real variation in the funding [across institutions], and yet physically those networks look virtually the same."

In addition to similarities in the physical structures of networks, there appears to be a group of services which are also common to many institutions. "Everyone has electronic mail. Everyone has a directory. Everyone has a campus-wide information system. Everyone has listservs."

Another element of the academic networked environment model is "the constituencies that make up the academic institution....administrators, staff, faculty, students, and the community."

And a final element is "the support structure...what's traditionally been called user services...helping people along, helping them grow and mature in this kind of environment, enabling them to make full use of the resources."

The purpose of conducting these two focus groups at this point in the investigation was to inform the design and implementation of the planned case studies. Specifically, we sought to ground our future data collection efforts in an understanding of the current state of networking at academic institutions based on empirical evidence.

The results of these two focus groups provided evidence to support some of the assumptions on which this study is based yet seem to indicate that some other prior assumptions were incorrect. Also, the focus groups identified a number of issues which had not been considered in the original design of the study. The following conclusions were drawn from these focus groups:

- Clearly, the growth of, and interest in, networking at academic institutions are increasing rapidly. Networking is becoming an essential part of academic institutions.
- There is interest in measures of extensiveness, as related to networking, and academic computing professionals regularly use a number of simple measures of the range and capacity of their systems.
- There is not a great deal of interest in the application of traditional financial models to the evaluation of networks. Focus group participants seemed to agree that these traditional models are not useful and they are under little pressure to provide economic justification for networks. They also agreed that there is little evidence to support a justification of networks on the basis of economics: they don't believe that networks have lowered institutional costs.
- There does not appear to be much of a challenge on the part of academic administrators to the idea of networking. Instead, there is much agreement about the necessity and value of networking.

- Networking has come to be considered a utility by users and providers. It is no longer something which is optional.
- There may be a certain minimum level of network capability required to attract and retain both faculty and students.
- The real value of networking is in what kinds of activities it enables which could not have been supported at all in a non networked environment.
- The full advantage of networking may not be realized until new pedagogical models are developed. Currently, many existing educational processes are being automated, but those processes are not being redesigned to take full advantage of network technology.
- Networks are becoming increasingly complex and therefore more difficult to support and maintain.
- Networks are becoming increasingly difficult for academic computing services to manage because of their distributed nature. As users become more sophisticated, technologically, they are able to assume more responsibility for the management of their own network technologies and services.
- Existing technologies are lagging behind user demand.
- The availability of information resources in the networked environment is lagging behind user demand.
- As demands for network technologies and services grow, and academic budgets shrink, investment in, and support of, other resources and services within the institutions may have to be cut in order to support networking.
- Evidence of the impacts of networking on academic institutions is primarily anecdotal at this point.
- The absence of good measures of teaching, research, and learning prior to networking will make it difficult to assess networking's impacts.

It appears that there is an almost universal acceptance of the importance of networking in academic

institutions, and little pressure to identify financial benefits associated with the costs of developing and maintaining network technologies and services. However there is a growing interest in developing methods to assist users in taking full advantage of the new technologies and in providing information resources which users can access via the networks.

4.2.3. Demographic Survey of Focus Group Participants

Following are summaries responses given by the university computing focus group participants and the CNI focus group/small-group interview participants to the demographic survey questions.

UNIVERSITY COMPUTING:

Professional Experience. Table 4-1 shows that most of the participants were mid-level managers with limited ACS experience. Four participants worked in ACS for 3 years or less, and only at their current institution. The other three participants had more than 10 years of experience in ACS. This group had technical expertise, but their perspective of the academic networked environment lacked the comprehensive overview of upper-level managers.

Table 4-1. Professional Experience.

Type of Position	Length of Time in Current Position	Length of Time in ACS
Director 2	0.25 - 3.5	10 - 16
Sr. Consultant 1	2	19
Manager 3	1.3 - 3	1.3 - 3
Programmer 1	1.25	1.25

Responsibilities and Expertise. Four of the respondents were responsible for the technical aspects of the network, and two others provided service support (e.g., instructional technology services and helping the faculty with all their computing needs). The four participants who

managed the network listed the following responsibilities:

- Coordinate development, deployment, and support for central network services
- Manage network infrastructure and Internet connection
- Manage network design, support and troubleshooting
- Manage the CMS provided Novell servers and AUX services.

Whether managing the system or providing support services, all the participants dealt with the network and information infrastructure as a primary responsibility. Participants listed four general areas of expertise :

- Network infrastructure
- Operating systems
- Applications
- Management.

Six participants listed some aspect of the network infrastructure as an area of expertise. Some of these areas included ethernet, TCP/IP, LAN and the Internet. Four participants listed operating systems, such as UNIX and desktop operating systems, as their areas of expertise. Two participants listed expertise with the following applications:

- Interactive video
- Classroom presentation
- Instructional design
- Social science applications.

Only two participants listed management as an area of expertise.

Evaluations. There was no consensus with respect to formal evaluations as most of the participants were unable (or unwilling) to answer these questions. This was more likely a reflection of their position within computing services. Two participants said that user studies are conducted as part of IT planning and evaluation, the others either didn't answer or answered no. If user studies were conducted, it does not seem that the data were distributed to all computing

service personnel. In response to a question about their personal evaluation of the school's information infrastructure, six participants rated their institution as "Slightly Better" than peer institutions and one rated it as "Much Better."

The participants listed the following criteria for assessing their institution's information infrastructure: good infrastructure (described as wiring and wiring plant, distribution of high-speed lines, and network design), reliability, performance, service, access and good support personnel.

Challenges. Participants identified the following challenges to providing a good infrastructure: training (of support personnel, end users, and "the computer illiterate."); and technical challenges (such as staying up-to-date and making the right choices for the netware software).

CNI:

Professional Experience. All but two of the participants in the CNI focus group/small-group interview held major positions within their institutions' academic computing services departments. One participant had left an academic institution to become the director of a consortium, and another was a university librarian. Ten participants each had at least 10 years of experience in academic computing, one participant had 40 years of experience, and all of the participants had major positions within the academic computing services hierarchy (see table 4-2).

Table 4-2. Professional Experience.

Current Position		Length of Time in Current Position	Length of Time in ACS
Director	4	2 - 11	10 - 40
Deputy Director	7	1 - 14	2.5 - 22
Manager	1	0.25	7

Responsibilities and Expertise. Eight participants were responsible for supporting, coordinating and managing their Campus-Wide Information System (CWIS) and information

technology. The CWIS includes: desktop computing, Internet access, public computer clusters and academic/administrative and telecommunications computing. Only one of the participants listed education of end users as a job responsibility.

Half of the participants listed management as an area of expertise; nine listed computer networks and networking as areas of expertise. Strategic planning/vision was an area of expertise for three of the participants.

Evaluations. Six participants said that their institutions had conducted evaluations of the network and computing services within the past three years. (Two of these six participants were employed by the same institution.)

Participants said they used informal, rather than formal, evaluations to compare their institutions to others. Table 4-3 compares the informal rating of the infrastructure by institutions with regularly conducted evaluations to those institutions which do not conduct evaluations. Perceptions of the quality of the infrastructure were similar regardless of formal evaluations being conducted.

Table 4-3. Quality of Infrastructure.

Evaluation Network?	Quality of Infrastructure
Yes	Much Better - 2 Slightly Better - 3 Same - 1 Slightly Worse - 0 Much Worse - 0
No	Much Better - 1 Slightly Better - 3 Same - 1 Slightly Worse - 0 Much Worse - 0

Participants considered the infrastructure and universal access to the network as the most important criteria used to assess the overall quality of their institutions' information infrastructure.

When discussing the infrastructure, they listed the following criteria:

- Penetration and diffusion of departmental computing
- State-of-the-art technology
- Ubiquitous connectivity
- Reliable performance
- Robust networking
- Extent and capacity of the network.

Services such as end-user support and training as well as the nature and array of services were also considered when evaluating their institutions. One participant whose institution evaluates the network stated that a survey of user satisfaction was one of the criteria used in judging his infrastructure as "Much Better" than peer institutions.

The two participants who rated their institutions "The Same" as peer institutions used the following criteria:

- Access to administrative information
- Universal access
- Degree of end-user support/training
- Universal service
- Reliability
- Cost-effectiveness.

Unique Services. In response to the question of unique network services, participants offered the following:

- Client software, Internet, Gopher, Popmail
- On-line library resources
- E-mail
- Bitnet information services
- Network ID and password

- Access to institutional data
- K-12 Access.
- Museum informatics project
- Meteorological data
- Genetic databases.

Challenges. The challenges identified by participants were primarily in the areas of user services and technology. Participants listed:

- End-user training to take advantage of investments
- Curriculum change to take advantage of the investment
- Ability to provide home-access to full constituency
- Collaborative effort for teaching and learning
- Education/use of networks by faculty
- User training and assistance
- Ease of use of systems.

Technology challenges identified included:

- Sufficient bandwidth
- Wireless frequency allocation
- Networking disparate systems
- Organizing information on the network
- Seamless integration.

Other challenges included:

- Security of information balanced against access
- Intellectual property rights issues
- Freedom of speech issues and censorship
- Ability to develop new policies for electronic resources.

When comparing the demographic data from the university group and the CNI groups, it is

important to remember the differences between the participants' positions within academic computing. The university group was composed of "hands-on" middle management personnel and the CNI focus group and small-group interview were comprised of upper-level managers. In spite of these differences, some patterns emerged.

Both groups considered information technology, the infrastructure, and the network as the backbone of the networked environment. There were no clear definitions of this terminology. The participants used all these phrases interchangeably. This lack of standardization of definitions made it difficult to accurately assess some responses. User services, accessibility, user training and support were also considered important parts of the academic network.

Because the methodology used in this approach was an evolving one, focus group results helped identify questions and issues to be explored during the site visits. For example, it was not clear from this survey why some institutions do not evaluate their networks. Is the network too distributed? Is it growing too rapidly? Is the technology changing so quickly that studies would be out of date before they were completed? Are the institutions so busy trying to build a system that they cannot stop and evaluate it? These questions were addressed later, during the site visits.

4.2.4. CNI Feedback

The data collected in the initial focus groups were then used to develop a preliminary model of the academic networked environment and a trial set of measures to assess the academic network. Members of the study team presented this model and the trial measures in a project briefing session open to attendees at the 1995 Spring Meeting of CNI. Approximately 50 people attended. Following the presentation, the study team members conducted a group discussion of the model and measures. The objectives here were to refine the model and measures, collect data on assessment activities at other academic institutions, and identify possible host institutions for site visits. Following is a summary of the group discussion:

- Critique of the model. Participants suggested that the preliminary model be revised to show linkages among the various components, especially between users and applications.
- Critique of the measures. Participants suggested a different categorization scheme for the measures: institutional measures, service measures, and individual measures. Also, they suggested that there be a stronger emphasis on measures of quality and satisfaction.
- Anticipated difficulties. Participants acknowledged the importance and potential usefulness of the measures, but at the same time expressed concern about problems associated with collection and analysis of assessment data. Specific problems they identified were: difficulties in generalizing from the data; reluctance of the parties involved to release such data; and the lack of resources available for data collection and analysis activities.
- Suggestions. Participants suggested that the study team contact accrediting agencies which have had experience with assessment efforts. Also, representatives from two academic institutions which has network and computing assessment experience volunteered to provide additional information on their efforts.

As a result of this group discussion, the study team made a number of changes in the focus and design of the study and in the assumptions on which the study was originally based. Most importantly, we expanded our focus to include performance measures as well as impact measures. And we also modified our expectations concerning the current state of network assessment; clearly less was being done in actual practice than we had believed. This information, along with additional information from follow-up contacts with participants, was used to modify the model and measures and to select locations for site visits.

4.3. Site Visits

The study team selected and visited two academic institutions for the primary purpose of testing and refining the draft performance measures and the Academic Networked Environment (ANE) model. Members of these institutions assessed the measures in terms of their feasibility, usefulness, cost, and accuracy. The study team compared the ANE model with the existing network in each site visited. Thus the site visits informed the continued development of the performance measures and the ANE model.

A secondary purpose was to develop detailed descriptions of the academic networked environment at the selected institutions. These descriptions serve as examples of the types of network configurations that are possible in academic institutions. Additionally, the site visits were used to gather more in-depth information about previously identified issues and to help identify new issues.

The site visit is an investigation of phenomena in a real life context. As such it is a variant of the case study method. However, unlike the case study, the site visit typically consists of a single visit, is somewhat informal, and the focus is on current, rather than historical, events (Yin, 1994). Sites are selected according to criteria relevant to the particular investigation. Data may be collected through a variety of methods; typically, a combination of methods is used. Analysis is primarily qualitative, but may be quantitative as well.

The study team selected potential sites from those institutions which constitute the larger sample for this investigation: those colleges and universities which are classified by the Carnegie Foundation for the Advancement of Teaching as a Research University I or II and which are members of ARL. The following additional criteria were used to select two sites from that group of institutions:

- the institution was within reasonable proximity of Syracuse,
- the institution has demonstrated advanced development and implementation of network technologies and services,

- individuals at the institution were interested in the research project,
- and these individuals were willing and able to participate in the site visits.

Also, there was a need to contrast a private institution with a public one. Thus, one private and one public institution, both of which met all of the criteria above, were selected.

Within the selected sites, study team members met with and interviewed numerous individuals and groups involved in networking on the campus. This included: university administrators; directors and staff of computing services departments; library directors and staff, especially those involved in the electronic delivery of library access and materials; faculty involved in network use, policy and planning; and students.

Using a theoretical sampling approach (Glaser & Strauss, 1967), some individuals were selected before the visits as the people most likely to be involved in networking. When interviewed, those people identified other individuals who were also involved in networking and these other individuals were then interviewed as well. Details on the numbers and types of individuals and groups interviewed are presented in later sections on each site visit.

Data were collected during the site visits via interviews with individuals and small groups, tours of facilities, observations of services and staff interactions, and collection of relevant documents. Study team members taped some interviews, and took notes on all interviews and observations. Interviews generally took an hour to an hour and one-half to complete. Interviewees were asked to complete a short demographic survey of their background and expertise related to networking and evaluation. Additionally, the study team collected data from casual conversations while at the sites and through telephone and email contacts following the visits.

The following questions were used to loosely structure the interviews:

- What is the current state of networking and evaluation of network performance at this institution?

- What key issues currently affect successful evaluation of networked information services?
- What are the respective roles of computing services, libraries, vendors, and users in the evaluation process?
- How would interviewees assess the usefulness of the performance measures proposed by the study team?

Each member of the study team who participated in a site visit performed a content analysis of her or his notes and, where available, the tapes from the interviews. Study team members combined their individual analyses of the interviews with their observations made during the site visits and with additional information obtained from relevant documents collected at the sites. Analysis of the data was guided by the questions listed above. The individual analyses were combined into a single document and reviewed by individual members who participated in the visits. Thus, the final analysis is based on multiple perspectives of the site. The interviewees raised topics and issues over a broad area but only those responses and views that bear directly on project topics are reported here.

4.3.1. Private University Site Visit

Three members of the study team interviewed five individuals involved in networking at the selected private institution including representatives from the libraries, networking group, instructional services, and support services.

Results of the interviews are organized here according to the following categories: general issues related to the development of the manual and project topics, the current status of networking evaluation on campus and attitudes toward evaluation, and reactions to the performance measures manual distributed to the interviewees prior to the interviews.

Interviewees raised a number of issues regarding evaluation of network activities and services. To a large degree, they raised these issues indirectly, as part of the interviews, and not by specifically noting that the study team should "really pay attention" to a particular issue.

Focus of the measures. The primary focus of this project has been on academic computing. However, many of the measures proposed may apply to all computing on campus. For example, when measuring the flow of network traffic over the network it may not be possible to parse out academic computing from administrative computing. Measures like the number of email messages which travel across the network will include email from academic groups, including faculty and students, as well as administrative groups, like deans' and registrars' offices. Both academic and administrative computing are encompassed in such a measure.

Intended audience for the manual. The original intention was to direct the manual towards computing administrators and centralized computing services only, in view of the problems associated with trying to measure the performance of distributed units which are not under central control. However, the interviewees stressed the importance of the distributed units at their institution and said that to ignore these units would present a distorted view of the computing environment. They suggested that the study team enlarge the focus of the manual to make it more useful for those in distributed units.

Central computing measures versus departmental measures. Related to the above issue, it became obvious from one interviewee that there is a need for, and an interest in, these measures among the distributed units. This particular individual had much interest in developing measures that would be useful specifically in one college. However, not all measures will be appropriate for all departments, and comparing across institutions and across departments might be problematic. Nonetheless, this individual indicated the need for measures that he could use in his particular setting and noted that, at this institution, different academic units counted networking activities differently and it was unclear if central computing could "force" agreement on how to define and count certain network activities/services.

Distributed versus decentralized networking. A distinction was made between the distributed environment and the decentralized environment. The distributed environment is one in which technologies, services, and support are distributed across the campus, but responsibility for the technologies, services, and support is centralized. In a decentralized environment technologies, services, and support, as well as responsibility for them, are distributed across campus. Interviewees urged that the manual recognize this distinction and relate it to evaluation.

Production of monthly statistical reports on networking activity. Apparently there are a number of units on campus that produce regular statistics. A monthly report on traffic is produced from central computing services. Unfortunately, members of the study team were unable to meet with individuals responsible for this activity. Additional information about this process as well as example reports were obtained later.

Understanding relationships among possible measures. Interviewees were especially interested in having measures that might assist them in determining how resource allocation for one type of activity might affect another activity. For example, one person commented that additional resources being committed to the help desk might be "throwing money into a dark and bottomless pit." Thus, if the university *increased* expenditures for network training and instruction, would *reduced* expenditures be needed for the help desk? Interviewees were interested in the degree to which the measurement manual would address such relationships.

Network sniffers and probes for evaluation. When asked about the extent to which central computing could measure traffic or other aspects of network activities, the response was, "When a problem occurs, we attach a sniffer to that particular router or server to find out what is happening." The term "sniffer" refers to hardware/software that network management would connect to a system component where a problem occurred to "sniff" out or probe the problem. But the cost of attaching sniffers to the network is significant, and could only be done on a "sampling" basis for short periods of time for purposes of evaluation.

The selected private institution has significant networking resources in place and is planning for its next network configuration which will be ATM (Asynchronous Transfer Mode) to the desktop. Within this context, however, there are numerous issues and problems that the university faces, as summarized below.

Evaluation of network activities and services is a "good thing." In general, all of the people interviewed agreed with this view. But they also agreed that none of them conducts evaluations regularly. There was an underlying assumption that the network is a good thing and that the need for it is essential and growing. Therefore, the interviewees explained, evaluations to determine what's wrong with the network, or whether the network is necessary, are not needed. As one interviewee said, "It's not like I'm going to come out with an earth-shattering study that's going to prove technology is worthless and we're all going to go back to books. It's not going to happen."

Inequalities of computing resources. A network administrator described the university as a very heterogeneous environment, where

> "...some college units are relatively resource rich and some are relatively resource poor and it's got more to do with the historical situation than with anything that's evolved because of the structural needs of the information technology. Addressing that imbalance is going to be one of the immediate items on the agenda over the next few years, addressing it in some formal, systematic way...and addressing where the line is between central and distributed support."

He recognized that having some type of performance measures could assist them in dealing with this issue, and, over time, determine the degree to which "progress" in equalizing resources had been made.

Non-systematic collection of networking data. There was evidence that some data on network performance are being collected, by different units and by different people. However, there is little evidence that the data are being collected and analyzed in a systematic way, or that they are being used in planning and decision making. Interviewees agreed that having a central

management information system (MIS) that identified, collected, organized, analyzed, and reported selected networking statistics would be an important step forward and was essential for improved planning for networking services. They also noted a range of problems and issues that would have to be resolved if such an MIS were to be established at this particular institution.

Reaching agreement of networking terms and evaluation procedures. An interesting discussion took place regarding the use of different procedures and different terms for the evaluation that was currently being done. There was little confidence that central computing services could obtain agreement from other stakeholders on campus as to the appropriate definitions to be used in a larger institutional effort on evaluation. One person commented, "it would take an act of God to reach such agreement."

Overview of barriers to ongoing networking evaluation. Several reasons were given for the lack of systematic data collection and low priority placed on evaluation activities.

- Some interviewees were suspicious of the goals of evaluation. When asked what his response would be if his director asked for this type of data, one person said, "My first question would be, 'What are you going to do with it?'"
- There are "power pockets" throughout the university and a grossly unequal distribution of resources. Thus, some groups have a vested interest in not sharing information about their resources lest they be pressured to share those resources.
- Individuals charged with providing network access to a growing, and an increasingly demanding, group of users may not have the time and resources to conduct evaluations. Their focus is on keeping the network running and meeting users' demands for speed and power. As one administrator described it, "Life is very simple for me as a network planner. I need to keep figuring out how to get the best, biggest, fastest, cheapest pipe in here possible on the presumption that the need for bandwidth is going to get bigger and bigger and bigger..."

- The lack of support (e.g., additional resources, a graduate assistant to do data collection, etc.) to conduct such evaluations and for some, limited knowledge on how to conduct such evaluations is also a barrier. One person indicated that before he would feel "comfortable" doing such evaluations, additional training would be needed.
- The lack of incentives to conduct such evaluations. While generally agreeing that evaluation was a good thing, they also noted that there were few tangible and direct incentives for conducting such evaluations. As one person commented, there was not an institutional mindset supporting ongoing evaluations.
- The oftentimes confusing distribution of technologies and services, and responsibilities for managing those technologies and services, compound the problems associated with evaluation: it is not always clear who is responsible for what. A number of the participants commented that they were unsure who did what in terms of networking or were unsure who should be contacted to solve a particular networking problem.
- There are considerable difficulties in defining key networking terms and services in such a way that they can be operationalized for measurement. Thus, before evaluation can occur, the institution may first have to reach agreement on how to operationalize key networking activities for measurement.
- The recent rapid growth and change in networking makes evaluation and planning extremely difficult. It is not always possible to predict the next direction in the technology. "I remember when someone said, 'Who needs a laserwriter? What are you going to do with that?' And desktop publishing. Nobody could have predicted this stuff."
- Networking infrastructures, services, and administrative organization for networking change rapidly, making evaluation difficult in such a volatile

environment. For example, on the day that the study team conducted the interviews, the Vice President for Computing announced a re-organization of the management responsibilities for computing services on campus.

In summary, interviewees agreed they would evaluate network performance if:

- someone ordered them to do so,
- they believed that the results would bring them additional resources,
- they could expect to receive additional personnel to conduct evaluations,
- they had training in evaluation methods,
- and they had the time to conduct evaluations.

In preparation for the visit, the study team supplied interviewees with a description of six proposed measures from the draft performance measures manual. The study team was pleased to note that most of the interviewees had read these proposed measures and some had made a number of margin notes as a basis for their discussions with the team. Following is a summary of the reaction to the manual and measures.

Identifying issues that require institution-specific responses. The approach taken in the manual, which presents issues associated with data collection and analysis and then leaves it up to individuals to resolve those issues in the context of their own organizations, was generally accepted. Interviewees recognized that it would be impossible to propose data collection techniques that could be used in a range of different institutions. They also agreed that before any type of data collection could take place, the institution may need to develop a range of policies and guidelines for how the data will be collected. Those policies would have to come from the institution and not from the manual.

Receptiveness to the ideas of measurement and to measures the study team proposed. Interviewees generally liked the measures that were presented although they also wanted more

detail on procedures. One person commented that if he had such a manual now, it would greatly assist him in conducting such evaluations.

Inclusion of anecdotal information and assessments. Interviewees urged that the study team not disregard anecdotal evidence of the impacts of networking. The network administrators interviewed said that they have used anecdotal evidence to help support their requests for resources to improve their networks and they themselves value such evidence. They also agreed that they need training in the methodologies used to collect, analyze, and present such evidence. A section in the manual that discussed techniques to systematically collect, organize, and report anecdotal information could be very useful.

Use of focus groups rather than, or in addition to, a user survey. One person said that instruction in techniques to obtain assessments from users other than surveys, such as focus groups, would be helpful. He believed that user surveys could require more time than available, whereas conducting focus group sessions with selected types of users could yield equally useful information while requiring less time.

More emphasis on impacts and effectiveness. One administrator described the measures in the manual as "...a good start at getting some reasonable measures that I would use in a tactical way to make decisions about capacity planning and that kind of thing." Yet, he said the measures fell short of conveying the true impact of networking on campus:

> "The thing that's really most liberating about the technology is the fact that it frees you from the constraints of time and space....it means that there are certain characteristics associated with it that have the possibility of enabling you as an information processing organism to do it differently than you've done it before. Look at things like feedback loops. It's possible to use the technology to get a quicker feedback loop. What does that boil down to in practical terms? The fact that I can access with very little effort all kinds of different opinions and perspectives on an issue. What I find myself wondering about is what is the effect of that developmentally, if you were to grow up with that kind of stuff."

Others commented, especially in the instructional arena, that measures showing use and knowledge of networks positively affected learning would be essential and that they needed such measures *now*!

Another individual suggested that the study team review the assessment areas in the CAUSE "Self-Assessment for Campus Information Technology Services" (1994) by Fleit to identify additional areas for possible impacts assessment.

Intended level of analysis of the measures. Several of the people interviewed made comments and asked questions which indicated that the level of analysis at which this research is being conducted is not clear. The measures proposed are, primarily, at the institutional level. That is, they are measures of network activities and expenditures for the entire institution. While there are effects of networking at the individual and group levels, the measures proposed are not intended to capture those effects. However, the measures proposed will form a foundation on which to build measures of effects at the individual and group levels.

Expanded introduction. Although not directly discussed by the participants, it was clear that any manual would need to have more information in the introduction that addressed the following:

- Benefits and uses of evaluation
- Considerations for measurement in a distributed computing environment
- Costs of evaluation
- Reporting and dissemination of evaluation results.

The consensus of the participants was that, while evaluation may be a "good thing," they all have numerous, competing responsibilities and a "good case for doing evaluation" should be made upfront in the manual.

Overall, the study team obtained much useful information from this site visit. We had hoped for a more specific assessment of individual measures than we received -- although some interviewees agreed to read through the entire draft manual and send us additional comments. The emphasis, however, was on issues related to the importance, and use, of ongoing evaluation of networked information services and activities.

An underlying theme throughout the visit was the conflicting views and needs of central computing services versus departmental computing services for evaluation and assessment. The "distributed" environment significantly complicates the views and needs of various stakeholder groups regarding evaluation. Indeed, the responsibilities for computing support and services is "confused" at best and typically, faculty and staff are unsure where to go for what kinds of services.

A second underlying theme was the idea that a computing services group, a bigger and more sophisticated infrastructure, and more "state of the art" equipment and services are givens for an institution such as this one. As one interviewee commented, "Competition among leading edge institutions also drives the development of the infrastructure as much as anything else... we have to be as good as, or better than, MIT if we are going to compete." Thus, there is some sense that the networking infrastructure *will* be developed, *will* be extended, and *will* be made better -- regardless of any evaluation. Such a perspective somewhat limits the need for formal justification and accountability of the network.

A third theme was the identification and description of the various barriers affecting successful evaluation of the networking environment which permeated many of the discussions. To a certain extent, the academic institution historically has paid little attention to the evaluation of traditional activities such as teaching, learning, research, and service. Thus, many of these barriers have been in the way for quite some time. Some attention to how best to remove and minimize these barriers will be needed if academic institutions are to be "prodded" into conducting such evaluations.

Finally, this site visit points to the importance of, and need for, a performance measures manual that:

- Has flexibility in how it can be used in different institutions
- Identifies issues that may need to be resolved at individual institutions
- Is useful for both centralized and distributed computing and networking environments
- Explains the importance of, and need for, ongoing network evaluation *in addition to* a depiction of performance measures
- Recognizes that different institutions may be collecting data differently, and indeed, that within the same institution, they may be collecting the same data differently.

Clearly, however, the interviewees provided much support for the development of such a manual and looked forward to seeing one "in the near future."

4.3.2. Public University Site Visit

A selected public institution was the site of the second visit. Two members of the study team visited the site for a two-day period during which they gave a brief presentation on the research project, toured campus computing facilities and libraries, and interviewed individuals involved in networking. Twenty-six individuals were interviewed including high-level administrators in the computing services group and the libraries, as well as staff members from those areas, and members of the faculty and student body.

General issues related to networking at this institution are presented below. Issues specific to the libraries and to the computing services groups follow. These specific issues include: the current state of network evaluation and attitudes toward evaluation, and reactions to the proposed performance measures and manual. The users' perspective, from faculty and students, also is presented.

Interviewees raised a number of issues which they believed were important in understanding their approach to networking and evaluation at this institution.

A client-server approach to network operation and funding. As the university moved from a mainframe model to a client-server model of computing, the centralized computing staff maintained control over personal computers and the associated network software and applications programs. Likewise, the centralized computing staff maintained control over the budget, which was growing to support this expanded computing operation. However, this institution's current plan for network deployment and operation, which will take the network into 1999, presents a drastic change in philosophy. The centralized computing services group will continue to be the server, with the clients being the end users. Both clients and servers will have budget, budget justification, and operational responsibilities. Under this plan the total IT budget will continue to rise but the computing services group portion will remain constant or decrease slightly. The increases in the overall budget will be funded within individual user departments. According to one administrator, "This is a bold move in which departments will gain a sense of ownership at the expense of creating their own funding mechanisms. This plan is not necessarily the most cost effective but will spread the IT expenditures across a variety of more defensible ventures."

Shared responsibility is not easily accepted. The people who were interviewed shared a number of concerns over the move toward distributed computing and distributed budget responsibilities. First, there is concern over the loss of a centralized pool to cover expensive, special, and major projects. As one librarian stated, "How will a small library fund the digital conversion of its resources to share with others on the network? There must be a centralized pool for these major undertakings." Second, they have concerns over the enforcement of standards. The centralized computing group will publish guidelines and standards to insure inter-operability of distributed systems, but it is not clear how these guidelines and standards will be enforced and what the consequences of ignoring them will be. A final concern has to do with inequalities in resources across the campus. While some units may be in a position to fund all the services they

need, other units may not. One interviewee added, "People don't trust upper management planning. They don't believe the central budget will drop. They think CIT will still maintain control and shift funding responsibility to the individual departments."

New roles for the centralized computing group. Under the networking plan, the centralized group has a continuing and major function in academic networking. They will maintain responsibility for the campus distribution system, the transmission of information throughout the network, and connectivity between the campus network, outside users, and information sources. Their responsibility for computer terminal equipment and applications will cease. Although the centralized group will offer consultation, advise, maintenance, and repair, on applications and terminal equipments, for a fee, they will no longer be responsible for budgeting, funding, or obtaining these pieces of the network.

Libraries as trainers and guides. The library is asserting itself into the role of trainer-guide to information content. As stated by the head of library services, "There's a vacuum in this area of training, [computing services] provides access but doesn't deal with applications or content. Libraries are filling that void in teaching users about electronic information. Some students now arrive on campus with experience in the use of electronic sources. It is our job to provide services to them while getting others up to speed."

Budget re-alignment. The library systems at this institution are the main users of the information network. They have already begun meeting user demand for electronic access by realigning their budgets. There is little or no new money available, so less is spent on printed materials and more on electronic support services. This realignment of spending will continue as libraries move from an attitude of acquiring assets to one of acquiring access.

Shared resources. There will be a vast amount of sharing of library resources via networking in the near future. With new emphasis on understanding and design of electronic inter-

library loan systems, the goal of the library is to reduce purchases of shelf materials, minimize duplicate copies of holdings, and to focus on electronic access to materials held in other locations.

Sharing reduces the value of ownership. In addition to funding required to build the network, the information content itself has a price. Libraries contain valuable collections that could be shared on the network. That sharing however, will reduce the intrinsic value of the asset. Some method of compensation must be created. Authors, and their estates, own works that are held within the library. These holding libraries must somehow be reimbursed or they will have no incentive to share their valued resources.

Network user fees. There is ongoing discussion concerning the degree to which centralized information technologies (e.g. wiring, routers, and Internet access) should be budgeted from the common construction fund, much like roadways. In a move designed to alleviate a portion of the current IT budget shortfall, students at this institution will be assessed an IT user fee of $60 per semester. This new fee will not initially provide any new services. The monies collected will be used to expand the campus data network and to offset some existing departmental budget constraints. The allocation of these monies between CIT and individual departments has yet to be decided. The administration expected student protests to begin as soon as students arrived on campus. This will, in turn, generate requirements for analysis and defense of the proposal and for the services provided; a further justification for network measurement and evaluation techniques.

Informal evaluation. There is no formal, ongoing program of evaluation of network technologies, resources, and services offered through the campus libraries. However, library administrators and staff are interested in measuring the degree to which they are meeting their users' needs. As one participant said, "If you're constantly asking yourself questions then there's a better chance that you're doing something right than if you basically say, 'Hey, we're doing great.'" Currently, library staff conduct informal evaluations in a variety of ways and rely on

users, faculty, and librarians at other institutions to provide information which can be used in evaluating the network.

Observations. One participant described the library's primary approach to evaluation as "keeping our eyes and ears open." Heavy use of network terminals, defined as those times "when we get people piling up to use them," is interpreted as a positive evaluation of the network. From such observations, staff infer the users' satisfaction with the resources and the need for additional terminals. Repeated problems with certain network services, or the lack of use of certain services, are interpreted as negative evaluations.

Staff members added that there have been instances when their perceptions were found to be in error after observations were made. "We thought that the big use for online reference would be evenings and weekends. [We found] weekend use was virtually nothing, there was some evening use, but most of our questions came in during the hours that we were sitting at reference desks. Sometimes conventional wisdom and what actually happens are at odds."

Use statistics. To a limited extent, statistics on use of network services and resources, specifically those resources available via the OPAC, are collected. "We generate monthly statistics on the types of searches that are being done and the databases being searched." Those statistics have been used in making decisions about which resources to offer and in what form, but they have not been analyzed extensively. "We've used [the statistics] to a certain extent to manipulate the configuration of databases and to maintain certain index and abstract products....But [the analysis] is on a transaction basis. It could be one person doing a million searches for all we know....I'm not satisfied that we've done nearly enough evaluation."

Focus groups. Library staff also have used focus groups as a means of evaluating the electronic resources they provide. After a series of focus groups of students, conducted to determine the appropriateness of online databases offered, a number of changes were made in both

the content and means of access to those databases. The following excerpt from a report on these focus groups identifies several areas where changes were needed:

> "...more graduate researchers would be inclined to use the system if a greater span of years was offered....Better publicity, instruction, and perhaps even signage seems to be indicated....Release 5.0.2 will facilitate progress in this area. Help screens will be better and an improvement in index screens will be apparent. A less cluttered display may promote more reading of instructions and, therefore, more self reliance."

Faculty evaluations. Staff also rely on faculty evaluations of student work as an indirect evaluation of the network services they provide. One librarian described a recent situation, brought to her attention by faculty, which indicated that students were in need of additional training in the use of online resources. "The quality of the students' papers was going down. They weren't using secondary sources. They were only using sources they found online." As a result, changes were made in the academic program and in library instruction to educate students in the differences among information resources.

Peer institutions. Finally, staff also rely on librarians at other institutions to provide feedback and recommendations concerning network resources and services they offer at their institutions. In making a decision to offer one of a number of similar resources, library staff might call peers at other university libraries to ask for their opinions of the resources.

Overview of barriers to ongoing networking evaluation. There are a number of reasons why there is not a formal, ongoing program of evaluation at the libraries. They include: existing attitudes toward technology and toward evaluation, a lack of resources, and organizational and environmental conditions. These barriers are elaborated on below.

- Positive attitudes toward technology. There is an underlying assumption that networking is a good and necessary thing. This assumption, shared by those at the highest level in the organization, is driving development of the network and is interpreted as a signal that evaluation in order to justify the network is unnecessary.

As one staff member explained, evaluation for the purpose of obtaining technology resources has not been necessary:

"We essentially lost acquisitions money this year with one hand while they were giving us automation money from the other hand. They're saying basically that technology is the way we have to go....There's the general perception upstairs that technology is good and that we should move toward it. It's a means to access information that we're not going to be able to buy or locally own."

Staff members indicated, however, that this perception could change. Until now, technology has been acquired and implemented using "an ad hoc budget." That is, there have been no regular budget allocations for technology in the libraries. They speculated that, once the cost of technology is built into the library budget, there will be institutional expectations for evaluation and justification.

- Results of previous evaluations have not been useful. Staff members said they have not found the results of previous evaluations to be useful or applicable. "I don't think [past studies] have told us much we didn't know sort of instinctively." Also, "It's hard to do anything with what you get. You get mixed signals, there isn't one clear message. Everyone's so different. They use things differently, they learn a different way. [This] makes it hard to do anything with what you hear. People approach [network technologies, resources and services] different ways. Their sophistication is different....If you really studied something you would see such a range of needs and whatever, you would be overwhelmed. There wouldn't be a [single] solution."
- Lack of personnel. The library's online public access catalog (OPAC) collects data on use of the system. However, the resources available to analyze the data are limited. "We find that we generate these log files but that the manipulation of those files could easily be a full-time job for a person. Therefore we basically do ad hoc

requests....The log of public searches is a way to evaluate the system somewhat. The problem is we can't do that every day and it's very dangerous to draw a lot of conclusions looking at a day's worth [of data]." Also, there is no MIS to handle the data collected and no overall evaluation strategy within which to analyze the data.

- Lack of research expertise. Furthermore, it's not just a matter of having additional staff to analyze data, but rather it's a matter of having staff with the appropriate skills and experience.

"What a lot of us are struggling with here is the fact that research is not easy to do. Any research requires understanding of the methodologies involved, it involves careful preparation and thought to design it well and work to analyze and interpret the data....we're all practicing professionals with day-to-day responsibilities for managing services and resources and not all of us have a formal background in research methodology. And there's a learning curve to do it well."

- Lack of precedents for evaluation. Like other organizations studied for this project, there is not a history of evaluation at this institution. It appears that many of the barriers to evaluation of network resources and services also were barriers to the evaluation of other resources and services. As one participant said, "It's a little strange to ask what do we do to evaluate things now when this is a question that was never asked in a pre-network environment."
- Organizational structure. Other barriers to network evaluation may be products of the structure of the organization. One problem is that the structure is not always clearly defined. Deciding where one element of the structure stops and another begins is not always an easy matter. For example, it is not clear, in the case of a statewide project, where the responsibilities of this institution end and the responsibilities of other state institutions begin. One participant explained why this

is the case. "We've been trying to blur the institution boundaries as a whole. We've been talking about statewide purchasing of databases. We've learned that we can do 50% of our interlibrary loan within [the system of state institutions]."

Another problem is the complexity of the organizational structure, which is mirrored in the design of systems to provide information, and which complicates data collection for evaluation. "Any system that we have is going to be complex if we replicate the organizational structure of the library and that's what we were trying to do....That stands between us and getting easy information."

- Rapidly changing environment. Another barrier to network evaluation is the speed at which new technologies become available and old technologies become obsolete. Staff members find it difficult to anticipate new technologies. As one person described the problem, "We don't know what [research and development] is going on in the rest of the world. I don't know what [research and development] is out there and is going to float on the scene any minute." And this rapid development and obsolescence of technologies makes evaluation difficult. "When you're talking about networking, things happen so fast that it's hard to put that kind of effort into evaluation of something that, by the time you get the evaluation done, you may be on to something else or something has changed....We can't spend three weeks developing a report that's useful but it's useful in regard to a dead technology." For example, "I don't want to spend a lot of time evaluating CD ROMs because I'm already looking at networked databases."

The library staff members who were interviewed agreed that: there are a variety of problems with evaluation of the network, previous attempts to evaluate have not been terribly successful, and the situation at this institution is typical of others. As one person described the situation:

> "My feeling about evaluation is that it takes a lot of time, you're never sure you're doing it right, and then I'm always finding myself in situations where after you've done it you never actually do anything with it or let it really inform something you're doing. I think there are barriers somehow...psychological barriers...organizational barriers....I don't think it's unique to this situation."

To a certain extent, the barriers to evaluation which the library staff members identified reflect a lack of understanding of the multiple purposes of evaluation. The staff members viewed evaluation as a means to justify resources and services offered to patrons and as an aid in decision making about the number and variety of resources and services to offer. This limited view of evaluation also is a function of the administrative level of those interviewed. Most of the people interviewed were involved directly in patron service and support. However, at a higher administrative level, there was a better understanding of evaluation and an appreciation for the need to evaluate networked resources and services in a larger organizational context. For example, the library director commented that she has been asked questions concerning cost benefit analysis of certain resources and services; questions for which she does not have, and would like to have, the information to answer.

Study team members provided participants with copies of the draft performance measures manual in advance of the site visit and interviewed these participants individually and as a group to get their feedback on the manual. Their comments, about the manual in general and about individual measures specifically, are summarized below.

Usefulness and usability. Participants agreed that the proposed measures would be useful and that the instructions given in the manual for collecting and interpreting the data would be helpful in using the manual. As one person stated, "Personally, in my day-to-day work, I could use a lot of these things and I like the way you define things and operationalized things. I could use some of these answers."

Someone else commented that the instructions and advice given in the manual concerning sample selection would be particularly helpful. "I did notice that you addressed sampling and that's appropriate. There's no way you could measure everything. I think sampling is a good thing to include."

Another participant observed that the proposed measures are especially useful when compared to other measures that are currently available, such as statistics published by ARL.

> "There were a lot of sets of statistics that were published annually that were good for a while, but now they're not real helpful anymore because they're not measuring these things. They're not asking the modern questions, [concerning the impacts of information technology and networks] unfortunately. They just count, how many of these do you have, how many of those. They're quite detailed but they're not useful."

Inclusiveness. Participants also responded positively to the inclusion in the manual of performance measures for groups outside of the libraries, such as computing services. "What I like in this document...personally, as I try to promote things on campus, I'm very dependent on the performance of [computing services]. When I tell someone to call the help desk, I say to myself, 'Are they really going to get help? Will they find a courteous person? What's the response time going to be there?' And there's a lot of that built in here."

However, some participants said that the measures failed to identify all groups involved in networking, including other on-campus groups, such as schools and colleges which work with the library to provide network resources and services.

> "It still seems like an approach where you're counting things for some discrete unit, some institution. But if I have access to someone else's institutional resources, that doesn't come in here very easily. If I was trying to apply this to the library it doesn't count that we are trying to do things with the engineering department and we have access to their resources in a way that maybe is not even specified."

Others suggested that the measures might be amended to reflect the participation of vendors in campus networking. For example, if a network service offers access to a variety of databases, provided by a variety of vendors, there should be some measure which distinguishes between the databases and permits evaluation of them separately.

Basic measures. Participants agreed that the basic measures proposed, the Count of Network Users and Annual Information Technology Expenditures, are of primary importance and that the definitional problems associated with these basic measures can only be resolved by individual institutions.

Need for measures of connectivity. Participants suggested that other useful measures would be ones which would indicate the degree to which faculty and students have access to the network and where they have access to the network. They suggested that what's needed are measures "...that would give institutions a way of saying how we are doing in general in getting our community into this electronic network of information resources. The extent to which the community is connected to the network...how many people have some sort of connection from their offices or dorm rooms or whatever. We're still struggling with that on this campus. It's a big issue--how quickly can we get all the offices wired. So some basic measure of connectivity of faculty, staff and students to the network."

Need for gross figures. Participants suggested that general statistics on use would be more powerful in their institution than statistics on who is using what and when they are using it. "Figures like the hundreds of thousands of transactions that we see everyday against the system are figures that we use and figures that are appreciated because of their magnitude. But I don't think [decision makers] stop and think, well who is doing this? Is it the faculty? Is it the students?"

Need for comparative institutional data and network configurations. Participants expressed concern that it would be difficult to compare various institutions using the proposed measures. "The whole tone in education now is one that sees technology as something that is good and that makes this school competitive with other schools. A lot of evaluation is how we compare....One of

the first things we were asked when we started thinking about moving to Unix was 'Well who else is thinking about that?' And when you say Columbia and Cornell are thinking about that...that means a lot." The kinds of information the library staff would like to have about other institutions include, "Information about an internal network, a server-based system, who's on it, what does it have on it, can you dial into it, what else can it get to, things of that sort, what are they costing..."

Need for data on use of specific resources. Library staff also are interested in measures of the cost and use of specific information resources. "If I had data on the [use of] journals in my collection and I had data on the [use of] databases that we had mounted on the network and I could compare the use and the cost per use that would be something that I could use very, very easily. Now, when I talk to faculty they say this is great, we've got to have it. But when I say it's going to cost $20,000 and we're going to have to cut nine journals to do it, they say oh...but if I could show much more specifically that we were getting much more bang for the buck it would be worth it."

Additional measures. Participants stressed that the proposed measures tell only part of the story. In addition to the measures in the manual and the measures suggested above, they would like to see the manual include the following: a user survey, methods for collecting and analyzing qualitative data, methods for collecting and analyzing anecdotal data, and methods for collecting and analyzing longitudinal data. (Note: The first three items listed above were in development at the time of the site visit but were not available for review at the time these individuals were interviewed.)

Need for measures of quality. A final concern had to do with measurement of the quality of network services and resources. "How do we make the jump from quantitative numbers to numbers that can help us evaluate the quality of what we're doing? It's easy to say we're spending this many dollars to provide this many workstations to provide access to this many databases, but so what?" However, the individuals interviewed were unable to describe specific measures of quality which they would like to have.

Likelihood of using the manual. In spite of participants' positive comments about the manual, there was some doubt that they would actually use the manual, even if the changes they proposed could be incorporated. "In an ideal world, theoretically, yes, I think we should and need to be collecting these kinds of data and analyzing them on a regular basis. But, realistically, I don't think...I think we'd have a hard time convincing ourselves and those above us that the work and effort involved in collecting these in a systematic and effective way would have the highest priority."

The major concern of participants was the resources required to actually implement the proposed measures. "A lot of this would be wonderful, to have the information, I'm just wondering how much we'd have to invest. My programmer could work a whole year on this, setting it up....But realistically, unless we had a research officer that was hired to be on this campus to do this kind of thing, I don't think those of us who are here would do this."

Preference for broad guidelines instead of specific measures. Participants suggested that another type of approach would have a greater likelihood of being implemented in their institution. One person described the preferred evaluation instrument as, "A set of guidelines. A series of questions [to be used as] a sort of accreditation process. A set of self evaluation questions you ask yourself periodically. And if you can answer yes to most of those questions, then you're probably doing a good job. Rather than counting things you're asking yourself a series of questions. 'Are we doing these kinds of things.'" Participants pointed to the CAUSE/EDUCOM Evaluation Guidelines for Institutional Information Technology Resources as an example of this type of approach.

Preference for small-scale projects. Also, participants suggested that a narrower scope would be more manageable. "I think [what we need are] periodic, smaller-scale, focused research projects, with careful methodology, from time to time, that one can then publish or get in the literature and cite as a backup, that it is true that these technologies are having an impact. Those

would be focused, smaller-scale projects, rather than trying to, on a very large scale, collect all this kind of data and try to evaluate it."

While the individuals who were interviewed at this site were generally supportive of the team's approach to evaluation, the manual, and many of the individual measures, they also expressed some reservations. Their primary concerns were that: the proposed measures don't capture contributions by all parties involved in providing network resources and services, they may not have the resources to implement the performance measures described in the manual, and they don't have a clear understanding of how to interpret and apply the results. In order to address these concerns, the study team would need to:

- Expand the measures to include all networking participants, such as vendors and various colleges and academic departments on campus, or provide guidelines demonstrating how this might be done.
- Suggest, in the introduction to the manual, how institutions may use some of the measures to compare their performance to other institutions.
- Illustrate in the manual how these measures might be carried out on a longitudinal basis.
- Explain how the results may be interpreted and applied.
- Emphasize that the usefulness of any given measure will vary from institution to institution. Users of the manual should be encouraged to select measures from the manual which they feel would be useful and should be reminded of the value of individual measures.

The academic network at this institution is on the brink of transition from a centralized, tightly controlled environment to one with a distributed architecture, distributed funding, and multiple interdepartmental operational processes. In the past, the centralized computing group has been responsible for acquiring, providing, and evaluating all information technology resources at

the university. The change to a highly distributed environment will enhance the acquisition and provisioning of network components but will complicate the evaluation process.

Budgeting and funding. As documented in the organization's technology plan, and discussed during the site visit, central computing historically has been the major provider of financial support for information technologies for the entire campus. The current annual IT budget is at $20 million with 73% coming from the central unit. The 1999 projection of $30.4 million will reduce the central contribution to 46%. As CIT's budget responsibility drops below 50%, the ability to maintain control and to evaluate the total cost of the academic network will become more difficult. Interdepartmental teams will be formed to provide the required evaluation.

Network traffic statistics. The primary functions of the central group include acquisition, provision, and operation of the network. Evaluation techniques have been developed to facilitate these functions. Traffic measurements throughout the network that contains more than 100 sub-networks include daily counts of bytes, frames, packets, and modem port connections. These measures are primarily used for daily network operations and trouble analysis. They are also used to assess trends in sub-network activity that may dictate the need for network reconfiguration, and to ascertain needs for equipment additions. Network traffic statistics are posted daily on the Internet and may be accessed via the Worldwide Web. This posting provides an excellent storage environment, as well as easy access by personnel doing testing, maintenance, and network planning. This Web Server arrangement has been written up and received high praise in trade publications.

It would be advantageous to central computing to know the originating location of modem traffic to the campus. Since these calls originate within and travel over the public telephone network, the Automatic Number Identification (ANI) feature, the same feature used for incoming caller ID, could be used. However, studies have found more than 60% of the users have disabled this feature on their telephones negating this data collection opportunity.

Network extensiveness. The study team was surprised to find that only 50% of the staff and faculty offices at this institution are wired for direct network access, and that there are no plans for direct access from any of the 8000 dormitory rooms. Central computing does have a specific plan and timetable for the wiring of the remaining offices. The modem pool, which provides for access from the "un-wired" offices, dormitory rooms, and off-campus users, is under constant evaluation and was recently increased in size. The high speed, fiber optic, backbone network connects sub-networks, an off-campus hospital network, and the Internet, through distributed routers.

Quality assessment. According to the central computing staff, "The foremost quality measure is a network functioning without blockages and delays." From a maintenance and operations viewpoint, this is a viable measure. From the users' perspective, quality may be a totally different measure. Central computing has conducted online user surveys, but offered no specifics concerning content or results. Peer evaluations have supported the creditability of the network operation. Other universities and colleges have relied on the expertise of the central group, in network planning, design and technical evaluation.

In summary, a sophisticated system is in place to measure the day-to-day operation of the network and to pinpoint locations of network troubles. Since only 50% of the administrative and faculty offices on the campus are currently networked, there is also an ongoing measurement of progress in network extension. Funding for network deployment is monitored in both the centralized operation and within departments. Beyond these measures, there is no ongoing evaluation of network effectiveness or impacts on the mission of the institution.

Overview of barriers to ongoing networking evaluation. As shown above, evaluation is done in those areas necessary to keep the network functioning on a daily basis and within the budgeting and funding process. Beyond that, there is a lack of a formal, on-going evaluation scheme to assess impacts on the academic environment, for the following reasons:

- Assumption that "networks are good. "Until very recently there was little concern about the money being allocated and spent on computing and network systems. The belief that education and technology inherently compliment each other fosters an attitude of minimal concern for evaluation techniques.
- Assumption that "intuition is sufficient and probably better than numbers." Central computing personnel feel competent in network planning and design and use quantitative data only when necessary to analyze and fix problems. Basic trend information is used to show growth in support of the idea that the academic community needs and uses the network. Beyond that, equipment selection and deployment is done by intuitive processes. "The real question in measurement is, 'What gives you the biggest bang for the buck?' The idea of 'biggest bang' is intuitive and not created through evaluation."
- Lack of resources. Time, money, and personnel are not available to do evaluation beyond that necessary to build and operate the network. "Evaluation of budget requirements and network bottlenecks take most of our resources." "There are always three specific problems associated with measurement: it takes too much time, you are never sure if you measured the right thing, and finally, the measurements are not used for anything."
- Lack of knowledge on how to evaluate. "The research questions proposed within the study are excellent and important but can we really find any way of answering them?" This statement portrays the current state of affairs in network evaluation. "The people assigned to do evaluation are usually not trained as researchers. Developing evaluation schemes and interpreting the results requires understanding of methodology, thoughtful design, and a large amount of effort. Knowledge pooling and sharing of successful evaluation activities on other campuses will reduce this barrier."

- Evaluating a moving target. "The speed of change is awesome." The environment is changing so fast that it is difficult to develop a measurement. "By the time you have planned, implemented, and analyzed data in a measurement area, the need for the analysis will have passed. Today there is no such thing as long-range planning. Unexpected applications can greatly distort any measurement activity. We would be better off spending time trying to understand what research and development is going on rather than trying to measure what we know we have."
- Reduction of central control. As end users gain more control over the budgeting, funding, and equipment selection processes, the ability to evaluate the overall network will decrease. The boundaries between departments and areas of responsibility are no longer clear. "We will need definitions of what needs to be evaluated, why, and for what purpose. It will be hard to generalize from the results created by people of all different levels of technical sophistication, and different ways of looking at the same results. Without some department or individual calling the shots, no useful evaluations will result."

- Inequalities in resources and power. As the distribution of funds for network development and use becomes more widely dispersed, an environment of "power pockets" will emerge. Some departments will be more able to allocate existing resources to technology and to obtain outside funding through business partnerships. This will cause an evaluation dilemma in which disclosure of success in network activities may result in decreased funding from the common pool.
- User accounts. The current procedure at this institution is to provide each incoming student with an E-Mail user account during the registration process. There is no ongoing process to purge accounts of graduates or "dropouts" and therefore a count of E-Mail accounts would be an inflated number. UNIX E-Mail servers are capable of counting individual account activity but such data is not normally accumulated as no need has been shown.

In summary, there is a general feeling that networks are good and therefore their impacts must also be good. This feeling presents a barrier to additional funding and manpower without which measurement, beyond that required for daily network operations, will not be implemented. The speed of change in technology, user behavior, and allocated network responsibilities make measurement difficult. The unequal distribution of resources, both physical and knowledge-based, has created network power pockets. There is lack of desire on the part of individuals within these power pockets to evaluate, disclose, or redistribute their resources. The best sources of evaluation will come from the user community in its assessments of impact, especially in the areas of network accessibility and quality.

Members of the computing services group had the following reactions to the draft manual and the measures within it:

Basic measures are important. The consensus of the interviewees was that basic measures are important to set the foundation for specific measures leading to the assessment of impacts. Measurement of network extensiveness, growth, number of users, and expenses associated with network deployment and operation were deemed to be the best starting points.

Measures require associated benefits. "We cannot use the performance measures manual unless we are given extra resources. There is just no time to do this stuff. We would have to know how much it would cost and what the benefits would be for following the manual." This statement highlighted the need for the study team to not only detail the measurement procedures but also to articulate potential benefits that would result from such measures.

Minimal need for fine tuning. There was general agreement that the proposed measures of cost, number of users, network traffic, and support functions all provide a starting point for network impact evaluation. There was concern that fine tuning of these measures, (e.g. counting each and every user, or each and every packet) could complicate the process to the point of destruction. "It would be better to establish a consistent measurable base from which to do trend analysis than to make sure that we counted every user and every login."

Traffic measures in the manual are "right on target." The computing group praised the traffic measures section of the manual. They currently take counts of bytes and packets in much the same manner as the study team proposed. "We agree with the proposal for sampling data. Constant data recording provides just too much information. At [this institution] we do the sample counts at ten minute intervals."

The traffic measures at this institution are used to facilitate daily operations and for simple growth analysis and equipment planning. They are not specifically used to assess network impacts. They do not count traffic to specific applications. "Counts of total network packets, and counts of log-ins to UNIX servers are quite easy to obtain. Beyond that, to assess the application associated with individual packets is expensive and complex." They acknowledge that such data could be gathered by providing "network probes" or "sniffers" at specific network locations but the costs overshadow any perceived benefits. "Such devices cost in the range of $10,000 each, and we have 100 nodes in our network. We use these devices for trouble analysis but to deploy them for routine data collection would be cost prohibitive."

Since this institution made a decision not to wire dormitories for direct connection to the campus network, the modem pool takes on added significance. Similar to what the study team found during the other site visit, people at this site said, "No matter how much we expand the modem pool, we reach saturation levels. Many students will try connecting from their rooms before using the on-campus public clusters." It is considered important to monitor modem pool activity to look for sources of trouble but there is no policy to keep modem traffic below saturation levels.

Likelihood of using the manual. The basic traffic measures to assess network day-to-day operations, and to measure modem utilization, are probably in use in all but the smallest network environments. The use of these measures for trend analysis is fairly simple and is used to support funding and network expansion plans. Beyond that, the interviewees felt that "Additional gathering of quantitative data won't tell you much. What we need next are survey tools."

Need for qualitative measures. The interviewees expressed the feeling that cost measures and traffic measures are necessary for the daily operation of the network, but it will be subjective measures that indicate the real impacts on teaching, learning, and research. "It is by monitoring user demands for services, watching waiting lines at public clusters, and administering surveys that we will reveal the impacts. The qualitative, anecdotal data may not be as fundamentally sound as quantitative data but it will carry more 'weight' in the evaluation of impacts."

The quantitative traffic measures outlined within the manual were exact parallels to those currently is use at this institution. They are necessary for the daily operation of the network. Beyond that, the proposed measures will require additional effort and increases in required funding and manpower. It is unlikely that these measures will be used unless significant benefits can be articulated. At this time, computing personnel feel that they have a sufficient handle on the budget and that provision of a user ID for every incoming still is an adequate measure of the user population. What they desire in terms of further network assessment are inexpensive, qualitative tools to get the views of the user community.

In addition to the interviews with library and computing staff, the study team conducted group discussions with members of the faculty and the student body at this institution. Although they are less involved, generally, in evaluation of the networking technologies and services, their perspective is important to include. Following is a summary of issues raised by these groups.

Shared resources increase the amount of available information. The networked environment provides access to more information than otherwise possible, including original manuscripts, musical compositions, and medical records. The information on the network is better organized and is changing the very nature of literary research. The work of the student or researcher is no longer constrained by materials in their possession or in the physically accessible library. With the network, world-wide searches can be completed in minutes. The key to all these benefits is sharing.

Not all activities are easier "on-line." Sharing of resources provides value in many but not all phases of the education process. One student who gave high praise to network benefits said, "It makes my research work much easier." On the other hand, the reading of lengthy texts online is not desirable. He added, "I don't believe anyone would want to read Moby Dick on-line."

Enhanced classroom presentations. Within the classroom, the traditional "chalk and talk" lecture is being replaced with methods based on technological enhancements. This institution has an ongoing modernization program to equip all classroom facilities with electronic podiums. These consoles provide instructors with access to overheads, slides, and videos, as well as connectivity to the network. All presentation materials are digitized and projected with high quality. The network connection allows real-time information searches, downloading of sound bites and video clips, and distance learning opportunities.

Enhanced communications activities. From the students' perspective, networking has provided a convenience that they believe would be difficult to do without. In addition to improving the content of the lecture, networking facilitates communication between students and their instructors. Students said that faculty are more responsive to email than they are to telephone calls or office visits and that email responses are of higher quality because time is available within the communication process for research of the question and formulation of the response. Students also use the network to communicate with each other, with family, with friends, and with professional organizations and businesses when engaged in the job search process. The network also provides a valuable link to the institution after graduation.

Physicians and medical students were initially attracted to the network because of its novelty. They became extensive users after discovering that it provided fast access to current clinical data and enhanced communication with colleagues in remote locations. They tend to use e-mail for distant communications but prefer the telephone as the primary medium for local work.

This second site visit, to a public institution, provides an interesting contrast to the first, which was done at a private institution. These institutions are alike in that they face many of the

same barriers to evaluation. However, this public institution, and perhaps other public institutions, face a different set of administrative issues and budget constraints than private institutions face. The budget constraints faced by this public institution appear to create a greater need for, and impetus to develop, a network evaluation program. This second site provides an excellent example of how network traffic can be monitored on an ongoing basis and how measurements of network traffic can be aggregated and used to support decision making.

4.4. Final Focus Groups

After the site visits, the study team revised the assessment manual and the measures, based on feedback from the visits. Two final focus groups were conducted to "test" the revised manual and measures. The first was held at the same university as the initial focus group of the project and the second was held in conjunction with the 1995 Fall Meeting of CNI, in Portland, OR.

4.4.1. University Computing

Individuals from the university's computing services group were asked to read and comment on the revised manual and measures and then discuss their reactions at a focus group. Seven individuals participated in the focus group. Following is a summary of their comments and reactions:

- Explain assumptions. Participants suggested that the team explain in more detail the assumptions about networked environments that the manual is built on (e.g., the degree of centralization assumed).
- Centralized vs. distributed approaches. Participants suggested that the team distinguish between centralized and distributed approaches to networking and outline the implications for assessment.
- Value of Surveys. Participants agreed that the user survey included in the manual was an important addition which is likely to be widely used.

- Benchmarking. Participants suggested that benchmarking would be a valuable tool to add.
- Distance education. Participants suggested that there will be a growing interest in distance education and the relevant measures might be expanded.

Additionally, the participants commented on measures which would be particularly useful in their networked environment, problems they might encounter implementing the measures, and possible solutions to those problems. The information collected during this focus group was used to once more refine the manual in preparation for the final focus group.

4.4.2. CNI Portland

The purpose of this focus group was to obtain feedback, from high-level professionals in academic networking, knowledgeable about assessing academic networking, and with "hands on networking experience" on the revised draft of the performance measures manual.

Criteria for selection of focus group participants were as follows: individuals

- planned to attend the CNI Fall Meeting,
- were interested in the project,
- agreed to review a copy of the manual prior to the focus group, and
- were employed at a high level of either academic library administration or academic computing administration.

In an instructional letter to the participants, the investigators stressed the importance of developing specific and detailed recommendations that could be used to improve the manual.

Initially, each participant was asked to introduce herself or himself and to comment generally on the manual. Following that, the investigators used the broad questions listed below to guide the discussion. The investigators also encouraged the participants to raise any additional issues, problems, or questions not addressed by these broad questions but which they believed were relevant.

- To what degree are the quantitative measures, in part II of the manual, appropriate, feasible, and useful in academic institutions?
- Do you see problems associated with the implementation of the quantitative measures? If so, can you propose solutions to these problems?
- To what degree is the manual appropriate for use across a campus? In individual departments of an academic institution?
- Are the explanations of the qualitative research methodologies which may be used in assessing performance of academic networking adequate?
- Are the topics listed for investigation using the qualitative methodologies appropriate?

Two members of the study team moderated the discussion and took notes during the session. The same team members did a content analysis of the notes to identify problems and issues to be resolved in the next draft of the manual as well as other areas needing improvement. The discussion at the session provided a rich range of information that would assist the study team in revising and improving the manual. These suggestions covered a number of topical areas as out

General introductory comments by the participants at the beginning of the focus group characterized the project as timely and relevant to their understanding of the current situation in academic networking. Participants offered the following evidence to support the need for performance measures in academic networking:

- One participant's university currently is developing 21 critical measures against which performance will be measured and which will be tied to funding. This university's library will be responsible for developing performance measures for their unit.
- One participant is currently involved in the development of a symposium on academic networking and performance measures.

- One participant reported having used quantitative measures to evaluate networking and plans to apply qualitative measures in the areas of user service and satisfaction.
- Several participants reported that their institutions are interested in evaluating networking performance and are prepared to do so, provided they can find the appropriate tools.
- Several participants expressed a desire to use the performance measures manual, or parts of it, immediately.

Participants recognized that developing such a manual would indeed be difficult. Further, a number of issues and problems would likely not be resolved by the manual. Nonetheless, the project would "move us forward" in this area and should be completed as soon as possible.

Quantitative measures. The next topic discussed was the number and type of quantitative measures that had been outlined in the manual. In this section of the discussion participants suggested that language be incorporated for measures using logs that data from the logs should be compared to "sniffers" as a validity check. The use of sniffers for a range of data collection activities was met with different responses from different participants. Some thought they were excellent tools, others were not as certain. Participants made the following suggestions to improve specific measures in the manual:

Measure: Count of Network Users

The use of email addresses to count network users will be problematic in institutions that have multiple distributed email systems or systems which support a range of network use without email access. A count of the number of Internet connections to PCs on campus, if there is universal network access at the institution, could more accurately reflect the number of users. The various ways of counting users should be listed with the advantages and disadvantages of each.

Measure: Annual Information Technology Expenditures

Describe cost categories that are in greater detail and that are similar to cost categories in other widely used data collection instruments (e.g., NACUBO, IPEDS, and CAUSE). Users should be reminded that cost structures will differ from institution to institution, costs are often distributed, and there will be ambiguities in cost categories. Provide users with greater guidance in finding out how to identify the various costs for IT on the campus. Expand this measure to include service costs, e.g., the cost to provide a network connection [note that such measures are included elsewhere in the manual]. Distinguish between costs for baseline or core services and billable or add-on services. The sense of the group was that the total IT costs should not include the billable costs to departments or other units on campus. These measures should differentiate between services which users receive free of charge and services for which they are billed.

Measure: Online Library Catalog Measures

In some institutions, it may not be possible to separate online library catalog use from other uses of a workstation. There are different types of online library catalogs connected to different types of networking configurations. More detail on types of issues that will have to be addressed should be presented.

Measure: Help Desk

This measure, as currently written, assumes that the help desk is centralized. The definition should be expanded to include distributed help desks and instructions for evaluating these distributed help desks should be included. A discussion took place about having separate measures for "central" versus "distributed" help desk services. Another concern raised here was the inappropriateness of assessing the help desk on topics or problems that may not be the responsibility of the local help desk. Increasingly it is difficult to determine where the boundary occurs between the campus network and the external network in terms of "help."

Measure: Network Training

Training measures are "smooshy" (i.e., they may not be valid). Evidence of the adequacy and efficacy of training may show up in other measures. Therefore these measures may be condensed or eliminated. Also to be considered are the range of individuals and units that provide some type of training, e.g., the library.

In addition to these suggestions to improve measures, participants proposed the following new measures:

Measure: Count of Non-Users

Definition: members of the authorized service community who do not use the network.

Measure: Count of External Use

Definition: Many institutions will be interested in identifying external groups which they support (e.g., public schools and professional associations). This may be especially important in rural areas where other means of network access are not available. It may be more feasible to measure external *use* of the network than external users.

Measure: Cost to Support External Communities

Definition: amount of local resources dedicated to provide users outside of the institution with access to unique information or services. For example, such a resource would be a web page which is supported by the university and accessed by individuals around the world. The rationale for this suggestion is that heavy access to such resources will affect performance of the network

and that members of the university community will be subsidizing use by others outside of the community.

Measure: IT Productivity

Definition: The degree to which outputs of the institutions have been affected by networking [unfortunately, specifics on what these outputs are were not detailed].

Measure: Savings through Resource Sharing

Definition: A financial measure of savings achieved by sharing hardware, software or staff with other institutions, and by participating in cooperative arrangements such as consortia. Such a measure would require users to obtain cost data from external organizations and also determine procedures for computing "costs saved" or "costs avoided."

Measure: Benchmarks

Definition: Standards or points of reference in judging quality or value. Participants agreed that benchmarking approaches should receive greater attention and detail in the manual. They suggested that a section on benchmarking be presented with some sample benchmarks. Users should be given some guidance on how to choose institutions against which they should benchmark their own institutions. They also need guidance on how to conduct a benchmarking exercise and how to determine what types of activities might best be benchmarked.

Qualitative measures. The group discussed the level of detail needed for conducting the various qualitative data collection techniques and generally agreed that in some instances additional detail could be provided (e.g. focus groups). But generally, the strategy taken to provide sources for additional information was appropriate. Participants made the following suggestions to improve existing measures:

- Expand the listed topics for focus group discussion to include development, e.g., development of alumni.
- Apprise users of the value in establishing ongoing relationships with individuals who participate in focus groups.

Participants also commented on the need to link qualitative approaches with other data collection strategies outlined in the manual.

User survey. The group spent little time discussing the survey specifically although some topics received attention. Participants made the following suggestions to improve the existing user survey:

- Ask survey respondents what they would *like* to do with the network, not just what they are currently doing.
- Ask survey respondents to place a value on the improvements they would like to see in the network. In addition to asking users what they would like to see improved or added to the network, ask them what they would be willing to pay for those improvements and additions.
- Anyone planning to administer the survey, or parts of it, should be encouraged to find out if there is an office designated for coordinating surveys on campus. Such an office may be able to provide timetables for other surveys which would help manual users avoid conflicts and competition with other survey administrators. Manual users should also investigate opportunities to do cooperative surveying with other groups on campus.

There also was some discussion about the limited faith some participants had in conducting such a survey. The belief of some was that the amount of time and effort required for a low response rate, and the difficulty of obtaining approval at their campus to conduct a survey, limited the usefulness of surveys.

Advice to Users of the Manual. Focus group participants suggested that the following advice to be given to users of the manual:

- Users of the manual should be cautioned about the limitations of the measures for comparing institutions. There is a need for measures which can be used to compare institutions but such a comparison would be difficult or impossible with some of the proposed performance measures.
- Users should be reminded that the disjointed nature of computing and networking on many campuses may make application of the performance measures across an institution difficult or impossible.
- Users of the manual should be cautioned that there are privacy issues associated with collecting data for these performance measures and that action should be taken to protect individuals' privacy when these measures are used. Users should be urged to aggregate all data collected to protect the privacy of individuals. However, users should be warned that this protection measure is useful only on central servers.
- Users should be urged to measure networked services or activities which are growing or for which there is considerable demand so that they can better plan to meet that growth.
- Users should be urged to collect data on the proposed measures by different user populations within their institutions.
- Users should be urged to collect data on the proposed measures for different projects within their institutions.
- Users should be reminded that qualitative data may be useful only at a local level.
- Users should be instructed in ways to combine the data from the various techniques outlined in the manual, e.g., quantitative with qualitative, with the user survey.

- Users should be provided with advice and guidance on how best to present the resulting data to organizational officials and to best support their goals.
- Users should be urged to use the performance measures for tactical purposes as well as for strategic purposes. That is, they should use them to measure their success in meeting objectives and to compare their performance from year to year.
- Users should be given examples of how selected measures can be used to improve service, thus providing an incentive to use the measures.
- Users should understand that the process of performance measurement may be as important, itself, as the actual resulting data, i.e., recognizing that ongoing evaluation is an important component of network management.
- Users should be encouraged to "get out of their institutional setting" and see/assess what others are doing to evaluate networked services.

Participants also understood that "all the advice in the world still may not help some folks to evaluate networked services correctly." But they did agree that it was important to make the effort in the manual.

Advice to the Study Team. Participants provided the following general suggestions to the study team:

- Accrediting bodies will be interested in the proposed performance measures, and likely will use some of them in accreditation processes, but there are certain weaknesses inherent in these measures if they were to be used for accreditation processes. Where possible, these weaknesses should be eliminated and where not, individuals and institutions should be cautioned about the use of these measures in accreditation processes.

  A list of measures used by various accrediting agencies should be appended to the manual.

- Preface the manual with a statement explaining that it can be used by different kinds of institutions and is not seen as a tool to be used exclusively by Carnegie I and II research institutions.
- Consider dropping the word "manual" from the title. "Strategies, guidelines, and options" defines the document more accurately and will be a more appropriate indicator of its potential use.
- Consider moving some of the questions from section IV into the user survey.
- Consider conducting one or two case studies to test the manual at several institutions. The results may strengthen the case that evaluation of networking is worthwhile.
- Further specify and make consistent all definitions, especially definitions for the following terms: network, academic network, application, resource, service, and technology.

  Participants suggested that for the term "network" it may be less important for the manual to prescribe such a definition as it is to outline the issues that might help users of the manual come up with a definition that would work for *them*.
- Develop a definition of the nomadic computing environment.
- Include a self inventory to help users determine the nature, configuration, and extent of networking on the campus.
- Give a more thorough explanation of the goals of evaluation, which will vary from institution to institution.
- Be consistent with the use of headers and sub-headers throughout the manual as current use is oftentimes quite confusing.

Participants also recognized that it may be difficult to address all of the areas described above. Thus, the study team may wish to recognize, in the introduction, the areas that will require additional work and testing.

In summary, the focus group participants, who are representatives of the group for which the performance measures manual is intended, documented the need for and interest in the manual, suggested improvements to specific measures and proposed additional measures, and offered general suggestions and advice for users of the manual and for the study team. Throughout the meeting there was an underlying theme that participants recognized the difficulty in developing such measures and procedures. Nonetheless, the sense of the participants was that this effort was essential, that we not "get it all correct" the first time, that identifying possible approaches and detailing the issues and concerns that have to be addressed in a measurement process, and promoting the process for ongoing networking assessment will be a significant contribution. Indeed, a number of participants wanted to retain their draft copy of the manual for use immediately.

Following the focus group, two study team members gave a briefing on the project to the general membership of CNI. After the briefing, audience members critiqued the project and made recommendations for its improvement. Among their recommendations were:

- reorganize the manual so that the qualitative measures are first, the user survey is second, and the quantitative measures are last. The reasoning for this was that there already is a great deal of anecdotal information being collected, thus readers of the manual will identify most strongly with the qualitative measures and can benefit most from learning about methods for the systematic collection of this information over time.
- weed out all prescriptive recommendations and statements
- emphasize the need to measure longitudinally
- caution users of the manual that, because technologies and organizational structures are changing rapidly, these measures will have to be changed often.

They encouraged the study team members to complete the manual as soon as possible and make it available.

4.5. Academic Networked Environment Model

One outcome of this investigation is a model of the academic networked environment (ANE) (see Figure 4-1). This model was originally based on a review of the available literature and then revised numerous times throughout the study, in response to feedback from the focus groups, interviews, discussion, and site visits.

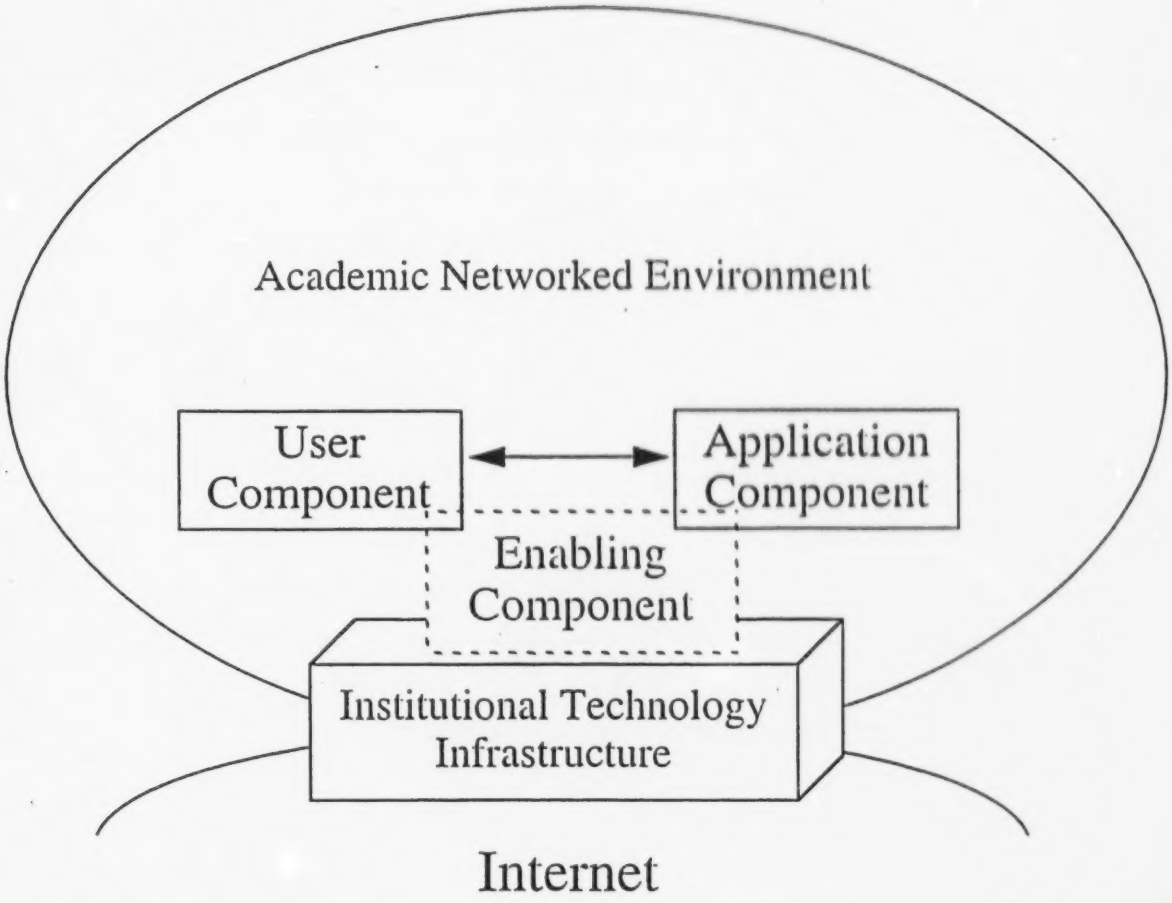
The proposed model is designed such that many assessment questions of impact can be empirically studied. The design has a simple physical nature to facilitate its application yet recognizes the complexity of the environment. As in the models previously reviewed, a simplification technique of "boxing" or "layering" has been employed. This division is somewhat artificial but facilitates understanding. By dividing the network into these logical groupings, one can more easily develop empirical tests and quantify the results. This technique does not reduce the value of the model and in fact is the only logical way to evaluate such a complex network.

The ANE Model has been constructed to facilitate understanding and examination of the components of the academic networked environment with the focus on measurement of the impact networking has had and will have on the institution. The model is intended to serve as a point of reference for discussing and measuring the scope and alignment of academic networked services.

Although many of the features and components of the ANE model are similar to those in models previously mentioned, each model, including ANE has its own specific purpose and design. The models, other than ANE, are systems oriented and are not designed with evaluation and measurement as key requirements. The ANE model is user oriented, flexible, and has been operationalized to facilitate evaluation and measurement.

The ANE model has four major component groups bounded by the perimeter of the institution. This perimeter extends beyond the physical boundaries of the institution only to include "off campus" connectivity of students and faculty into the institutional network. The component groups are described as follows:

FIGURE 4-1. ANE MODEL



- User Base: Within the ANE model, the user and the user's perspective of the networked environment are of major importance. The users, or customers, in this environment include teaching and research faculty, students, and administrators, in various settings within the institution. Users exist within the environment at all skill levels and must be considered the primary reason for the network's existence. The users drive the network and its new applications. However, their resistance to change may also present impediments to application upgrades. All users share a common desire for a system that is easy to use, available when needed, and reliable.
- Enabling: The ANE model exhibits its uniqueness with emphasis on those components of the architecture that "enable" the network's functionality. Very basically, these components act as the interface for all other network functions. User access to applications, through use of the physical infrastructure, is enabled from this area. Enabling services can be classified as campus specific or generic, and include distributed computing services, information management services, user interface services, and utility services. Providers of these services include Academic Computing, Information Management Services, Network Coordinators, and Communications Network Providers. Network services are developed, funded, and managed from this area. Enabler's often see themselves as utility providers, much like the water or power companies, and do not visualize all of the responsibilities associated with the enabling function. Enablers need to be both demand and vision driven and to meet user expectations at justifiable costs. They must also provide user training and help-desk activities. Enabling services must create an environment in which new services and applications can be easily introduced and integrated into existing services and applications. This component is thus expected to be an

especially dynamic one, with technical innovations and new service requests continually demanding attention.

- Technology: The technology component, also known as the physical infrastructure, contains the basic processing and communications components of the system. The physical connectivity and layout of the network and component systems are contained is this area. This portion of the model is viewed as the "backbone" of the architecture. The network speed, bandwidth, and system availability and reliability are functions of this area. Ability of the network to handle the transmission of voice, data, image, or combinations (multimedia) resides in the technology layer. This is an area of rapid transition in both speed and physical structure. Proper placement of infrastructure that allows for future enhancements at affordable costs is difficult but mandatory.
- Applications: This area contains all applications or processing tools that run on the academic network and actually "do something" for the user. E-mail, data search and retrieval programs, interactive education, and on-line registration are examples of applications. The quality and quantity of available applications constitute the usefulness of this component area.

The ANE model does have certain limitations. It was designed to facilitate analysis and measurement of impacts of the Internet on the institution. It is simplistic in design and categorizes functions and participants into manageable components. It is not designed as a technical model to guide

The enabling component, which may be thought of in simple terms as the network service provision component, is the dominant component and the "glue" that holds the overall network together. It is however more than just a service provision piece as this component includes planning, funding, training, and help-desk activities in addition to service provision.

The technology infrastructure, composed of computing and communications hardware and software, provides the backbone of the academic networked environment and the interface to other institutions via the Internet. This infrastructure, conceived, implemented, and maintained by the enablers, provides significant quantitative measurement opportunities. The extensiveness, and efficiency of this physical part of the network have major impact on user satisfaction and network use.

Although users can be categorized for measurement in terms of their position within the academic setting and their skill levels, the revised model also includes recognition of user ability to drive or provide applications. The interface between users and applications is much more significant than originally indicated. To simply measure user satisfaction based on applications provided by others is not valid as many applications are now individualized to user appliances. This puts additional responsibility into the enabling function to understand these individual applications and to provide as much inter-operability as possible between these diverse applications.

The applications area includes functions that exist within individual workstations, as well as those within the campus based public, shared, and research areas.

The ANE model is designed to facilitate measurement in the areas of extensiveness, efficiency, and effectiveness of the various components, leading to assessment of overall impact of academic networking on the institution.

4.6. Assessment Manual

A major product of this research is the manual, Assessing the Academic Networked Environment: Strategies and Options. A copy of the final version of the manual is attached to this report and the contents are reviewed briefly here. CNI has distributed the manual to its members at no cost and is distributing it to other interested parties for the cost of printing and mailing.

The manual is to be considered a work in progress. It is not a step-by-step guide to network evaluation. Rather, as the titles suggests, it is a collection of strategies and options which

institutions may consider in evaluating their networked environments. Some parts of the manual will be more relevant for certain institutions that other parts. Any given institution will need to select from and modify the measures, instruments, and approaches presented in the manual. Additionally there are a number of issues, also reviewed briefly below and presented in more detail in the accompanying manual, which must be resolved by individual institutions before they can use this manual. The way in which one institution deals with these issues may not be appropriate in other institutions.

The manual includes three sections: a discussion of the collection and use of qualitative data, a set of quantitative measures, and an instrument for surveying network users. While any of these sections may be used independently of the others, the manual will best be used by integrating the various parts. For example, the use of qualitative data may be informative, but the combination of qualitative and quantitative data with a user survey will provide a much more complete assessment of networking.

In the qualitative section of the manual, a variety of qualitative techniques for data collection and analysis are described. Strengths and weaknesses of each method are presented, and references are provided for further information on, and examples of, each technique. Also, a list of topics and issues, related to networking, which may be investigated using these qualitative techniques, is presented. And finally, strategies for the successful sue of these techniques are presented.

Measures for the assessment of networking are presented in the following broad categories: users, costs, network traffic, use, services, and support. For each of the measures in each of these areas, the following are provided: definitions of the measures; a discussion of issues which must be addressed before that measure can be used; instructions for data collection and analysis; a discussion of each measure; and additional suggestions for its use.

The final part of the manual is a survey instrument, accompanied by a discussion of issues related to the use of such an instrument as well as suggestions for administering the survey. The

survey is designed to collect information on the following: user demographics; data on users' experience with computers and their current habits and practices in using their campus network, including which resources and services they use, how they use them, and when they use them. Users are also asked to evaluate these resources and services as well as the network support services available at their institutions.

5. CONCLUSIONS & RECOMMENDATIONS

The purposes of this research were: to define and describe the academic networked environment and its component parts; to identify existing measures of network performance and impacts; to identify factors which facilitate or inhibit network assessment; and to develop and operationalize additional measures. The research questions, presented in the introduction to this report, which guided this investigation are reviewed below along with relevant conclusions from this investigation and recommendations for future research and practice.

- What information technologies and services comprise networked information, and to what degree are these similar across various academic institutions?
- Who are the "users" of networked information within the academic setting and how might we develop a typology of such users?
- What are the organizational structures used in academic institutions to provide networked information services?
- What are the key factors that appear to affect the overall success of the networked environment in an academic setting?
- What measures can be developed to assess the impacts of networking on the academic environment?

The academic networked environment exists in various configurations which may differ from institution to institution. There are some common elements of the networked environment, broadly defined in the ANE model presented here as users, applications, an enabling component, and an institutional technology infrastructure which connects to the Internet. In most academic institutions, users may be categorized as faculty, students, staff, and others. More specific definitions of users will vary from institution to institution. There are some applications which can be found in many institutions, including email, OPAC, CWIS, and WWW. But many other applications are specific to certain institutions. Likewise, the enabling component and technology

infrastructure are likely to be different in different institutions. Thus at a very general level, there is a model of the academic networked environment, but at a more specific level, each environment may be unique.

There is currently little assessment of academic networking. In part this is due to the variation among networked environments; there is no generic approach or set of measures which can be employed universally, nor is there likely to be. Additionally, there are numerous barriers to evaluation (e.g., lack of resources, time, training, tools and rewards), the technology is changing rapidly, and the environment is increasingly distributed.

However, there is a need for assessment of networking for purposes of planning, decision making, resource allocation, and meeting users' needs. What's needed first is development of an assessment mindset. That is, university and computing administrators must understand the importance of assessment and be willing to assign the necessary resources to the accomplishment of the task. Beyond that, useful measures, tools, and procedures must be developed. As this research has shown, there may not be a universal set of measures, tools, and procedures. However, the strategies and options developed during this investigation, and presented in the assessment manual, may provide a starting point for institutions to develop assessment programs. Any institution may find certain elements of the manual more appropriate than others and thus should pick and choose from the strategies and options presented. Assessment need not be an all-or-nothing effort.

While this study has produced a set of assessment strategies and options and identified issues which must be resolved, there is much more work to be done. The investigators believe that the next step in this effort should be to field test the manual in a variety of academic settings. That is, groups including academic computing and library administrators and staff should attempt to implement the measures and approaches developed in this study and the results of their efforts should be used to inform the further development of the manual. This will involve a commitment of time, effort, and financial resources from institutions which chose to assess their networking.

APPENDIX A

Coding Scheme for Content Analysis of IT Plans

- Benefits
  - Learning and teaching
    - Future
    - Student-faculty communication
    - Diversity
    - Distance learning
    - Learning materials
  - Research
    - Productivity
    - Data access
    - Cooperation
    - Results communication
  - Administration
    - Institutional data
    - Cost reduction
    - Reduction of bureaucracy
    - Efficiency
    - Decision making
    - Cohesion
  - Service
    - Alumni
    - Boundaries
    - Information transfer
- Objectives
  - Policies and procedures
    - IT policies
    - Distance learning
    - Security
  - Development of IT use
    - Student purchases
    - Curriculum
    - Faculty motivation
  - Services
    - Support
    - Training
    - Servers
    - Community
  - Network
    - Connection
    - Campuses
    - Internet
    - Interoperability

- Stakeholders
  - Funding sources
  - Research partners
  - K-12
- Resources
  - Funding
  - Student fee
  - Budget
  - Cost
  - Staffing
  - Hardware
  - Software
  - Supercomputing
- Organizational structure
  - Information officer
  - Central core
  - Decentralization
  - Planning
  - Coordination
- User involvement
  - Needs analysis
  - Advisory committee
  - Surveys
  - Liaisons
  - User groups
- Evaluation
  - Current evaluation
  - Necessity of evaluation
  - Evaluation methods
  - Measures

APPENDIX B

Code Definitions and Examples from Content Analysis of IT Plans

Following is a hierarchical listing of all coding categories used in the content analysis of the university computing strategic plans. Definitions are provided for first (x.), second (x.x), and third (x.x.x) level categories. Examples are listed under the most specific level of each category. These examples are sample phrases, taken from the plans, which were coded using those categories. The number of plans which include instances of each third level category is also given.

1. Category Name: Benefits
Definition: Expected positive impacts of implementation of the strategic plan, or of IT in general, on the university

1.1. Category Name: Learning and Teaching
Definition: Improvements to the processes of student learning and faculty teaching

1.1.1. Category Name: Future (3 plans)
Definition: Students best prepared for future job and environment
Example: "When students leave the university, they will be familiar with current technology, understand the implications of the information age, and be equipped and ready to contribute to their workplace and society"

1.1.2. Category Name: Student-Faculty Communication (8 plans)
Definition: Better communication between students and faculty through e-mail
Example: "'Connectivity' will allow faculty and students to easily communicate regarding assignments, grades, special instruction and counseling matters"

1.1.3. Category Name: Diversity (4 plans)
Definition: Increased exposure to diversity thanks to the ability of communicating with other students on campus and all over the world.
Example: "Telecommunications permits students to interact electronically with others throughout the world. This will be an increasingly important way for...students to learn about and accept other peoples and cultures, and to understand the unique role of [our state] in the international community"

1.1.4. Category Name: Distance Learning (7 plans)
Definition: Increased access to education for people who cannot be on-campus traditional students
Example: "The sophisticated network communications will make it possible for successful distance education programs to bring the best of [the university] to anyone, or any class, anywhere"

1.1.5. Category Name: Learning Materials (11 plans)
Definition: "Richer" learning materials thanks to multi-media, simulations, access to databases
Example: "Incorporating many technologies and using them to provide information in a variety of ways, such as through simulation exercises, computer-based tutorials, and multimedia learning experiences, will provide richness of content"

1.2. Category Name: Research
Definition: Improvements to the faculty research process

1.2.1. Category Name: Productivity (10 plans)
Definition: Increased productivity of faculty, without more specifications
Example: "Enhanced personal productivity, with appropriate information resources and computing tools, on campus and elsewhere, that are easy to use and readily available to faculty..."

1.2.2. Category Name: Data Access (12 plans)
Definition: Increased access to data (bibliographic databases, library catalog, electronic journals, data files, grant information) and computing resources
Example: "Prospecting in archives and repositories of scientific, historical and literary data and text will become far easier"

1.2.3. Category Name: Cooperation (12 plans)
Definition: Increased cooperation between departments of an institution or between researchers at different institutions
Example: "High potential exists for increasing faculty collaboration throughout [the university]...Researchers are able to interact easily with colleagues all over the world who may have similar, and perhaps very specialized interest"

1.2.4. Category Name: Results Communication (5 plans)
Definition: Improved communication of research results
Example: "Electronic distribution of articles already has reduced publishing lead times in some disciplines dramatically"

1.3. Category Name: Administration
Definition: Improvements to the administrative processes

1.3.1. Category Name: Institutional Data (13 plans)
Definition: Easy access to institutional data by staff and end-users (schedules, grades, financial aid, etc.)
Example: "The next generation of administrative systems will be developed with emphasis on data interchange and ease of use, not only by administrators, but also by faculty and students"

1.3.2. Category Name: Cost Reduction (5 plans)
Definition: Reduction of costs to perform administrative tasks and processes
Example: "A productive staff environment will result in cost-effective delivery of quality service"

1.3.3. Category Name: Bureaucracy Reduction (4 plans)
Definition: Simplification of administrative organizational structure
Example: "Each administrative office will find it easier to customize its work for the ultimate customers, and many intermediary administrative functions will disappear or be reduced in importance"

1.3.4. Category Name: Efficiency (12 plans)
Definition: Increased efficiency of administrative processes

Example: "The improved communications that will arise from information technology in the future will make our administrative staff more accessible and our administrative processes more clear"

1.3.5. Category Name: Decision-Making (5 plans)
Definition: Better decision-making thanks to decision support systems and better availability of data
Example: "More in-depth analysis of trend data and other information used to support decision making will occur because of increased data availability"

1.3.6. Category Name: Cohesion (3 plans)
Definition: More cohesive university
Example: "Campus wide access to new information services and to an integrated administrative data encyclopedia will contribute in important ways to this cohesion"

1.4. Category Name: Service
Definition: Improvements in service provided to the larger community

1.4.1. Category Name: Alumni (3 plans)
Definition: Allowing alumni to keep in touch with campus life; provision of services (career announcements, library catalog access etc.)
Example: "Special bulletin boards for alumni will permit them to keep in touch conveniently with former classmates, faculty, and other friends. Network access to...placement offices(s) will permit alumni to use those placement offices throughout their careers"

1.4.2. Category Name: Boundaries (5 plans)
Definition: Expand the service boundaries of institution into a wider geographical area
Example: "Faculty, staff, students, alumni/ae, and citizens...will be able to transact all necessary business, exchange and obtain information, and work collaboratively..."

1.4.3. Category Name: Info Transfer (6 plans)
Definition: Better transfer of information and research results into the community
Example: "Information technology can provide a convenient and timely method for informing the public about all that goes on within the university and for providing them with the opportunity to share in the benefits the university makes available within the community"

2. Category Name: Objectives
Definition: Stated, or implied, objectives of the plans

2.1. Category Name: Policies and Procedures
Definition: Development of policies and procedures

2.1.1. Category Name: IT Policies (14 plans)
Definition: Development of IT policies and standards
Example: "Document and communicate telecommunications policies....Clarify policies for charging and funding....Support of interoperability standards for local area networks"

2.1.2. Category Name: Distance Learning (3 plans)
Definition: Development of policies for distance learning

Example: "Develop policies that address crucial issues relating to instructional technology and distance education"

2.1.3. Category Name: Security (15 plans)
Definition: Development of policies and procedures to guarantee security and privacy of data
Example: "Define appropriate use, privacy, and security issues related to campus communications"

2.2. Category Name: IT Use
Definition: Development of IT use in the teaching/learning process

2.2.1. Category Name: Student Purchases (9 plans)
Definition: Incentives for purchase of IT equipment by students
Example: "Open access sites are needed to serve the large number of students who, for various reasons, do not possess their own personal computer. A greater penetration of computing technology into the campus can be achieved by encouraging personal ownership of microcomputers"

2.2.2. Category Name: Curriculum (11 plans)
Definition: Integration of IT into curricula, development of courseware
Example: "Computing will be integrated into all appropriate curricula, both specific and general education, to ensure a level of literacy and numeracy appropriate for a research university"

2.2.3. Category Name: Faculty Motivation (11 plans)
Definition: Concrete incentives for faculty use of IT in teaching and research
Example: "Include in the promotion and tenure process recognition and rewards for faculty efforts to improve the quality and range of instruction through the use of information technologies"

2.3. Category Name: Services
Definition: Services provided by computing services units

2.3.1. Category Name: Support (18 plans)
Definition: Adequate user support
Example: "There will be a single, readily identifiable source for help"

2.3.2. Category Name: Training (15 plans)
Definition: Adequate user training
Example: "Increase and appropriately schedule student seminars in the basic computing skills most useful to a broad range of disciplines")

2.3.3. Category Name: Servers (17 plans)
Definition: Development of information servers, such as Campus-wide information systems, library catalog, etc.
Example: "Develop a systemwide information system that provides a wide range of university information online, such as job openings, university calendars, course schedules, current events, athletic schedules and ticket information, campus bulletins, and student and staff directories"

2.3.4. Category Name: Community (4 plans)
Definition: Act as a provider of IT resources and support for the community
Example: "Support the creation of the community network"

2.4. Category Name: Network
Definition: Development of a network infrastructure

2.4.1. Category Name: Connection (18 plans)
Definition: Connection to the network of on-campus locations. Includes "electronic classrooms"
Example: "The university will have access to a distributed information utility from a variety of electronic work environments and from a variety of locations including home, dorm room, lab, office, classroom"

2.4.2. Category Name: Campuses (6 plans)
Definition: For multi-campuses institutions, adequate network links between campuses
Example: "Reduce geographic and informatic caste distinctions at the university by making resources available to the coordinated campuses"

2.4.3. Category Name: Internet (15 plans)
Definition: Adequate access to national and international networks
Example: "Provide connectivity and appropriate gateways to selected external networks which are consistent with the university's missions"

2.4.4. Category Name: Interoperability (17 plans)
Definition: Interoperability between different platforms and operating systems, common front-end interfaces
Example: "Access to the distributed information utility will be via a transparent and uniform interface"

3.0. Category Name: Stakeholders
Definition: Stakeholders other than the ones mentioned in all plans (students, faculty, staff, computing services)

3.1. Category Name: Funding Sources (6 plans)
Definition: External sources of funding
Example: " Seek additional opportunities to provide computer access to state agencies, federal departments and private activities which will generate additional revenue"

3.2. Category Name: Research Partners (9 plans)
Definition: Research projects involving external parties
Example: "Seek joint venture projects with equipment and software vendors in areas of special strength"

3.3. Category Name: K-12 (3 plans)
Definition: Collaboration with elementary and secondary schools
Example: "Provide the community, especially local high schools, with access to computing workshops, seminars, facilities and public information services"

4.0. Category Name: Resources

Definition: Inputs required to provide computing services

4.1. Category Name: Funding (17 plans)
Definition: Sufficient funding
Example: "Computing infrastructure requires adequate and predictable funding. Investments in computing and information resources should be justified in term of educational worth, research support, process improvement and/or administrative effectiveness"

4.2. Category Name: Student Fee (6 plans)
Definition: Necessity of establishing a student technology/computing fee
Example: "A number of major institutions have used such a fee to help pay for the cost of providing an adequate computing environment to their students"

4.3. Category Name: Budget (7 plans)
Definition: Budget procedures and resource allocations
Example: "The university...will adopt a new model for allocating resources for information technology ....The recommended model consists of a mix of 'free' and recharge components"

4.4. Category Name: Cost (8 plans)
Definition: Actual cost figures and budget requirements
Example: "Annual hardware maintenance: 10% of initial cost"

4.5. Category Name: Staffing (10 plans)
Definition: Adequate staffing, staff training and development
Example: "Hire more support personnel, at both the college and system level....The support staff themselves must be supported with training opportunities"

4.6. Category Name: Hardware (13 plans)
Definition: Purchase and maintenance of adequate hardware
Example: "Assist and support departmental acquisitions of more, newer, faster and more powerful workstations and servers"

4.7. Category Name: Software (14 plans)
Definition: Purchase and maintenance of adequate software, site licensing
Example: "Establish an integrated, campus-wide architecture of selected hardware and software"

4.8. Category Name: Supercomputing (12 plans)
Definition: Access (on-campus or off-campus) to adequate supercomputing resources
Example: "Provide support and access to national high performance computing centers through advanced networks and local support services"

5. Category Name: Organizational Structure
Definition: Formal arrangement of the organization

5.1. Category Name: Information Officer (5 plans)
Definition: Establishment or existence of a Central information officer at vice presidential level
Example: "The first recommendation is to merger and integrate key technology support units and establish a Chief Information Officer (CIO) at the University"

5.2. Category Name: Central Core (12 plans)
Definition: Central unit for network, support, guidelines, standards
Example: "There will be a single, readily identifiable source for help, support, and service with networks, computers, and databases"

5.3. Category Name: Decentralization (13 plans)
Definition: Decentralization for choice of system, planning, budget, support
Example: "In keeping with the generally decentralized structure of the university system, information technology functions will be both decentralized and centralized. Much of the end-user equipment, support, decision-making, and budgeting must occur at the college or unit level. There must be central responsibility for activities that require overall consistency or for which there are significant economies of scale"

5.7. Category Name: Planning (9 plans)
Definition: Establishment or improvement of the planning process
Example: "Goal six: planning. To integrate information technology perspectives into university level planning"

5.8. Category Name: Coordination (10 plans)
Definition: Coordination with other units (library, printing, media, etc.)
Example: "Work closely with the library, university museums, other collections, and academic and administrative departments to establish a rich set of online information resources and services"

6.0. Category Name: User Involvement
Definition: Indicators of users' roles in IT planning, implementation, and support

6.1. Category Name: Need Analysis (12 plans)
Definition: Decisions based on the analysis of user needs
Example: "Delivering high quality services demands extraordinary commitment by every member of Information Systems and Computing to understanding the needs of end-users"

6.2. Category Name: Advisory Committee (12 plans)
Definition: Existence of advisory committees including students, faculty, staff
Example: "The Faculty Advisory Committees, the Instructional Computing Advisory Committee and the Research Computing Advisory Committee will continue to advise the Provost and Academic Computing on computing policies and problems"

6.3. Category Name: Surveys (4 plans)
Definition: User surveys conducted to assess needs or satisfaction
Example: "Each organization responsible for the provision of such resources should periodically survey a sample of their users and measure their satisfaction and the degree to which they believe these several goals have been met"

6.4. Category Name: Liaisons (5 plans)
Definition: Establishment of a liaison with each department
Example: "Designate staff liaison for each major academic and administrative unit to be responsible for identifying issues and resolving questions relating to that unit"

6.5. Category Name: User Groups (3 plans)
Definition: Establishment of groups of student, staff, and faculty users
Example: "Encourage the development and growth of formal faculty support groups and informal user support groups"

7.0. Category Name: Evaluation
Definition: Indicators of attempts to judge the existence, extent, quality, and usefulness of IT and the institution

7.1. Category Name: Current Evaluation (5 plans)
Definition: Analysis of the current strengths and weaknesses of the institution
Example: "What follows is a straightforward assessment of the university's current internal capacity in key areas of information technology"

7.2. Category Name: Necessity of Evaluation (5 plans)
Definition: Importance of evaluation to process improvement
Example: "Quality standards must be defined and a quality assurance function formalized to ensure that performance is monitored and that services are continually evaluated and improved"

7.3. Category Name: Evaluation Methods (5 plans)
Definition: Methods of evaluation suggested or already in use.
Example: "Evaluate continuously new alternatives and the quality and effectiveness of existing information technology"

7.4. Category Name: Measures (4 plans)
Definition: Actual measures suggested or already in use
Example: "Since the introduction of [the conference system] in 1987, a strong computer conferencing culture has been established. As of December 31, 1990, there wee 285 conferences on [the system], with an average of about 4,000 new conference messages per month during the last half of 1990"

APPENDIX C

Initial University Focus Group Topics

1. How would you define and describe the networked environment at your institution?
2. Is the networked environment you are building, or have built, adequate for your institution?
3. How do you evaluate the networked environment at your institution?
4. At the institutional level, how are decisions made regarding the networked environment?
5. What factors have driven decisions to implement information technologies at your institution?

APPENDIX D

CNI Orlando Focus Group Topics

Evaluation

1) How do you know if the information infrastructure you are building, or have built, is adequate for your institution?

   What methods and what measures do you use to evaluate the infrastructure?

   Did you design it with a certain "quality of service" requirement in mind?

   What are the primary obstacles in conducting meaningful assessments of infrastructure costs, benefits, impacts, etc.?

   Do you use a benchmark methodology?

   Given the fast pace of information technology change, how do you assess the currency of the components of your infrastructure?

2) Have you, or others at your institution, been called upon to provide economic justifications for the resources you have assigned to the information infrastructure?

   If so, what measures and indicators have you developed to use in your justifications for what has been spent or in requesting additional resources?

3) If called upon by the administration of your school, could you identify and describe ways in which the academic networked environment has improved teaching, faculty research, student learning, and/or service?

   Are you able to isolate the effects of the networked environment from the effects of other variables?

Planning/Deployment

4) At an institution-wide level, how are decisions made regarding the networked environment?

   Is it a top-down process or are the decisions decentralized and driven by the individual departments?

Who are the key players -- within and external to the institution?

How do you coordinate the deployment of infrastructure components among the various units and levels of the institution?

What have been the primary obstacles to the success of information technologies once they have been deployed?

5) To what extent have the following factors driven the decision to implement information technologies at your institution?

Technological innovation and/or obsolescence

Competition with other academic institutions

Policy and/or planning

Infrastructure Model - Description

6) In all likelihood, networked environments in academic institutions are similar to networked environments in other types of organizations. However, it seems equally likely that the nature and mission of the university creates certain network requirements that are unique. Is it possible to generate a generic model which describes and typifies the academic networked environment?

What terms may we use to describe the components?

APPENDIX E

Focus Group Questionnaire

1. Name: _____ Email Address: _____
2. Institution: _____
3. Current Position: _____
4. Briefly describe your job responsibilities:

5. How long have you been in your current position? _____ years
6. How long have you worked in the administration of academic computing services? _____ years
7. Please list several terms which best describe your area(s) of professional expertise:

   _____ _____ _____

   _____ _____ _____

8. Have any major studies or evaluations of network and computing services at your institution been conducted in recent years? _____ If so, when? _____
9. What are two unique networked services you provide at your institution?

   (1) _____

   (2) _____

10. How would you rate the overall quality of your institution's current information infrastructure when compared to other schools of the same size and with similar missions?

    Much Worse Slightly Worse Same Slightly Better Much Better

11. In providing your answer to item #10 above, what do you consider to be the three most important criteria in making this assessment?

    (1) _____

    (2) _____

    (3) _____

12. What do you think are the three most important non-economic challenges facing your institution in the quest to provide the best information infrastructure possible?

    (1) _____

    (2) _____

    (3) _____

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